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COMMENTS OF ORMET CORPORATION

ON THE PROPOSED REMEDIAL ACTION PLAN

FOR THE ORMET CORPORATION SUPERFUND SITE

JUNE 9, 1994

APPENDICES VOLUME II

REPORT

OVERVIEW OF GEOHYDROLOGIC AND WATER QUALITY
DATA AND FORMULATION OF ALTERNATIVES

ALUMINUM REDUCTION PLANT
ORMET CORPORATION
HANNIBAL, OHIO

Dames & Moore
November 21, 1977
Job No. 7983-006-07

DAMES & MOORE

November 21, 1977

Mr. Charles Sheppard
Ormet Corporation
Hannibal, Ohio 43931

Dear Mr. Sheppard:

Enclosed are 4 copies of our final report "Overview of Geohydrologic and Water Quality Data and Formulation of Alternatives, Ormet Corporation, Aluminum Reduction Plant, Hannibal, Ohio." This report is in accordance with the scope of work outlined in our confirming proposal dated July 27, 1977, and your Purchase Order No. OH-12653 dated July 15, 1977.

Pursuant to your staff's technical review and our meeting of October 7, 1977, we have made certain revisions and additions to this report. We appreciate your cooperation and suggestions on this project and the opportunity to be of service to Ormet Corporation. We look forward to continuing to assist you in solving your water problems.

Respectfully submitted,

DAMES & MOORE

Dean O. Gregg

Dean O. Gregg
Senior Hydrologist
and Associate

DOG/lhk
Enclosures

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INTRODUCTION

Ormet Corporation's aluminum reduction plant is located on the Ohio River near Hannibal, Ohio. This plant once obtained all of its sanitary and process water from an on-site Ranney well. In recent years the water quality has deteriorated because of the presence of abnormally high concentrations of cyanides, fluorides, soluble organics, total dissolved solids, and of high color and pH. Only through the operation of two nearby interceptor wells is ground water from the Ranney well usable for process water. However, the pumping of the interceptor wells (operating alternately) has created hydraulic interference which in turn has lowered the production of this well. Because of the reduced production and the marginal quality water, all of the sanitary water and some of the process water is currently obtained from a well and a surface water intake, respectively, owned by Conalco.

At the request of Ormet Corporation, and in accordance to their Purchase Order No. OH-12653 dated July 15, 1977, Dames & Moore evaluated the water supply and the hydrogeology on and near the plant site. This report discusses the hydrologic conditions, the water supply, and suggests remedial measures and programs to decrease the potential for ground water contamination.

OBJECTIVES

The objectives of this study were as follows:

1. Assess the possibility of natural flushing of the aquifer and improvement of ground water quality;
2. Assess the likelihood of continuing to use Ranney Well No. 1;
3. Assess, if possible, recent increases in concentrations of fluoride, cyanide, total dissolved solids (TDS), color, and pH from Ranney Well No. 1;
4. Identify and assess alternative methods to reduce aquifer pollution;
5. Identify and describe data investigation needs, if any, to quantify the above; and
6. Identify possible alternative water supply sources.

METHODS OF INVESTIGATION

This investigation was performed by compiling, reviewing, and evaluating existing reports and data, by making a site reconnaissance, and by discussions with Ormet personnel. Of particular importance were a series of reports on geohydrology by F.H. Klaer, Jr., and Associates. The Corps of Engineers District in Pittsburgh, Pennsylvania, was contacted to obtain stage, discharge, and precipitation records for the Ohio River. Both the United States Geological Survey and the Ohio Department of Natural Resources were contacted to obtain available ground-water level records along the Ohio River. Evaporation data were obtained from the National Climatic Control Agency (Asheville, North Carolina). The nature of this project, Ormet's name, and the plant location were not disclosed to any agencies.

PLANT FACILITIES

PRODUCTION FACILITIES

Ormet Corporation's Hannibal, Ohio, aluminum reduction plant produces about 240,000 tons of primary aluminum from alumina annually. The alumina is reduced to primary aluminum in the presence of liquid cryolite (Na_3AlF_6) in electrolytic cells or "pots". The Hannibal plant has 6 aluminum pot lines containing 172 pots each.

In the process of making aluminum, large quantities of carbon anodes are required. These anodes, made on site at the carbon plant, are a steam-heated and baked mixture of petroleum coke and pitch. The plant recovers cryolite from spent pot linings for reuse in the reduction process.

Unrecoverable wastes generated at the plant are piped as a slurry to a sludge disposal pond located east of the plant. The solids largely settle out in the pond and the effluent discharges to the Ohio River.

WATER SUPPLY

Ormet Corporation currently uses an average of about 1350 gpm with a maximum of about 1600 gpm of process water from Ranney Well No. 1 (shown on Figure 1). This well was originally pumped at 2400 gpm with a maximum design flow of 3430 gpm to furnish all process and sanitary water to Ormet. Since January 1971, Conalco's Ranney well (Ranney Well No. 2), located approximately 2100 feet west of Ormet's Ranney Well No. 1, supplies up to 600 gpm of sanitary water to Ormet Corporation. In addition, Conalco furnishes about 600 gpm of river water to supplement Ormet's process water needs. These actions were necessary because of deteriorating quality of water from Ranney Well No. 1 by increased concentrations of fluoride, cyanide, and organics and by higher pH and color. Table 1 lists the water requirements for different plant processes.

Ormet Corporation projects that their water requirements will probably decrease over the next 5 years. By 1979, the wet scrubber system will be replaced by a dry scrubber system which will result in a savings of approximately 300 gpm. Over the next 5 years, existing water-cooled rectifiers will probably be changed to air-cooled units. The use of air-cooled rectifiers along with the air-cooled scrubber system will reduce total water use by as much as 1,800 gpm.

Two interceptor wells have been installed between suspected sources of ground water contamination and Ranney Well No. 1. These interceptor wells have been somewhat successful in reducing the overall concentration of contaminates in water from Ranney Well No. 1 by pumping some of the contaminated ground water out prior to its reaching Ranney Well No. 1. From 1971 until the last increase in stage of the Ohio River, the interceptor wells were pumped at less than 300 gpm. This was a sufficient rate to allow Ranney Well No. 1 to pump about 1800 gpm of acceptable quality water. In recent years since the river stage increase, the pumping rates in the interceptor wells have had to be increased from below 300 gpm to possibly as high as 500 gpm to protect the quality of the water from the Ranney well. The Ranney Well is only pumped at a rate of about 1350 gpm at present. The reduced capacity of the Ranney Well and the increased pumping of the interceptor wells may be due in part to a subsequent reduction in river contribution to the Ranney Well. This may have been caused by incrustation of the Ranney well laterals beneath the Ohio River and/or by silting in the river. A detailed test and inspection of the laterals would be necessary to verify the presence of incrustation.

SLUDGE DISPOSAL PONDS

General

Process waste water containing pulverized carbon, alumina, and cryolite not recoverable for plant uses are discharged into sludge disposal ponds located east of the plant (Figure 1). The pond bottoms are unlined and probably on the original ground surface, approximate elevation 632 msl (mean sea level). The dikes were constructed by building embankments of local material compacted by either sheepsfoot rollers or vibroflotation. These ponds are shown on Figure 1. The physical dimensions of each pond are:

	Surface[a] Area (ft^2)	Approximate Depth (ft)
Pond 1	47,000	10-12
Pond 2	47,000	10-12
Pond 3	41,000	10-12
Pond 4	91,000	10-12
Pond 5	470,000	23[b]

[a]Planimetered measurements from Figure 1.

[b]The top of the dike berm is at elevation 655 feet msl (August 1977). This elevation is currently being increased 3 feet to elevation 658 feet msl, or 26 feet above the probable original pond bottom (elevation 632 feet msl).

Operational History

Ormet's five disposal ponds have different operating histories. Ponds 1 through 4, the four smaller ponds shown on Figure 1, were used from 1957 to 1967. These ponds were originally designed for alternate use. One pond would be cleaned out while the others received sludge. Because sludge removal was found to be impractical, these ponds were used until they were filled with sediment and then abandoned. The slurry entering these ponds was initially untreated. About the upper 1 foot of sludge in the ponds is from later lime treatment and it contains calcium fluoride.

Pond 5 (Figure 1), operating since 1967, currently receives all slurry discharged from Ormet. Until 1974, sludge was discharged along the western side of the pond. The presence of "sink holes" along the eastern side of the pond initiated the extension of the discharge line around the pond to attempt to plug the holes with sediment (Ormet, 1977). Sludge is currently discharged to the pond from one of several discharge points located around the pond perimeter. This has distributed a more even sediment build-up in the pond and is believed to have been effective in "plugging" the "sink holes".

Because of ground water contamination, Ormet personnel attempted to lower the pH and to chemically neutralize the fluorides in the sludge after it entered Pond 5. Approximately 2 truckloads of hydrochloric and sulfuric acid were batch dumped into the pond to lower the pH and lime was added to precipitate fluorides. This method was found ineffective because of poor mixing and insufficient quality of the added chemicals. A neutralization plant was constructed and became operational in June 1977. The neutralization plant treats the slurry before discharging into the pond. About 1 truckload of acid per day reduces the pH to between 6.5 and 7.5; chlorination with sodium hypochloride removes most of the cyanide; and lime is added to settle out fluoride concentrations (Ormet, 1977).

Prior to April 11, 1977, there were no overflows from Pond 5 and the water surface covered only about 20 percent of the pond area. Since that time, some of the water from the interceptor wells has been added to the slurry, increasing the discharge volume to approximately 250 gpm. The pond is now full and overflows through a discharge line to outfall no. 4. The discharge rate should remain near 250 gpm because of the continued disposal of interceptor well water which is utilized for makeup water in the neutralization plant (Ormet, 1977). To attempt to define a water budget for Pond 5 on September 1, 1977, Ormet Corporation measured 274 gpm of slurry, containing 24.9 gpm of solids, entering the pond and 216 gpm of effluent discharging to outfall no. 4. Because these quantities were not precisely measured, it is not known if the difference, 33 gpm, reflects the total loss.

Leachate Quality

The chemical and physical characteristics of the leachate for Pond 5 varies greatly. The pond water was analyzed daily from January 1975 to present and shows that the pH ranged between 2.3 (in response to batch treatment with acid) and 12.1; fluoride levels were generally below 500 mg/l. An estimated average leachate quality is shown on Table 2.

WASTE POT LINING STORAGE

Waste pot linings from the aluminum reduction process are stored east of the plant and north of Pond No. 5 (see Figure 1). The unprotected storage of the waste pot linings allows them to soften which facilitates pulverization in the cryolite recovery process. The main constituents of the waste pot liners include:

Cryolite (Na_3AlF_6)	18 - 30%
Carbon (C)	30%
Aluminum oxide (Al_2O_3)	38%
Calcium fluoride (CaF_2)	2 - 4%
Sodium oxides and hydroxides	2 - 3%
Nitrites, carbides and cyanide	Trace
	(Ormet, 1977)

The chemical composition is as follows:

Aluminum oxide (Al_2O_3)	38%
Carbon (C)	30%
Sodium (Na)	17%
Fluoride (F)	10 - 15%
Calcium (Ca)	1 - 2.5%
Silica (SiO_2)	0.2 - 1.8%
Iron oxide (Fe_2O_3)	1.5 - 5%
	(Ormet, 1977)

It is reported that during open storage, the fluoride content of the waste pot linings decreases to approximately 6 percent by leaching from precipitation. The resultant leachate is estimated to have a high pH and fluoride concentration, with lower concentrations of cyanide and other constituents. Prior to the detection of high fluorides and increased color of ground water in the Ranney well in July 1971, Ormet purchased pot lining material from a competitor.

Although no significant chemical difference could be found between the Ormet pot lining and the purchased pot lining material, it was suspected that the introduction of that foreign lining may have been partly responsible for ground water contamination.

Ormet reported that the quantities of stored waste pot linings have been steadily decreasing since 1968-69 and are at the lowest levels since the plant's existence. Ormet plans to terminate additional waste pot lining storage by 1978 and to remove the existing waste pot linings from this storage by 1979 (Ormet, 1977).

FUGITIVE DISPOSAL

Within the plant area there are several areas of fugitive disposal which may be a source of ground-water contamination. These areas are:

1. dumps
2. outfalls
3. airborne emissions
4. miscellaneous temporary storage areas.

Dumps

Adjacent to the sludge disposal pond 5, Ormet currently disposes of construction and plant refuse. The majority of this material is carbon scrap, refractory brick, and metal (steel) with a lesser amount of wood and pasteboard. These materials are relatively inert and would likely produce little leachate.

Outfalls

Ormet currently utilizes four outfalls (Figure 1) which discharge effluent to the Ohio River. Outfalls 1, 2, and 3 discharge effluent to the Ohio River by pipeline or paved spillway. Outfall 4, which receives water from the carbon plant and from the waste disposal pond No. 5, discharges effluent to the Ohio River via an open ditch.

Total effluent flows for the outfalls was 2.98 mgd on July 7, 1977 and 3.74 mgd on July 21, 1977. Since July 1977 water samples have been collected for analysis the first and third week of each month. Table 3 presents chemical analysis of effluent from the outfalls during the two sample periods. It is believed that the gully containing outfall no. 4 has cut down into or near the top of the aquifer and that some ground water contamination may be occurring.

Airborne Emissions

Airborne particles emitted from plant processes consist primarily of carbon and alumina dust with trace amounts of fluoride. Periodic analysis of dustfall from a 5-mile radius surrounding Ormet's plant show fluoride levels less than 1 milligram per cubic foot per month (Ormet, 1977). Thus it is unlikely that airborne emissions would be a possible source of contamination.

Miscellaneous Temporary Storage Areas

Throughout the plant area spent pot shells are temporarily stored. These shells are partially cleaned but still contain some spent pot linings. Exposed to the weather, the pot linings are a potential source of a small amount of fluoride leachate to the environment.

GENERAL SITE CONDITIONS

TOPOGRAPHY AND CLIMATE

The topography at the Ormet Corporation Hannibal plant is characterized as a mature river valley with gently sloping alluvial terraces confined by steeply sloping hillsides. The plant site has an elevation of 665.5 feet msl with the nearby hills approximately 500 to 600 feet higher. The Ohio River is about 53 feet deep opposite the plant and has a pool elevation of 623 feet msl.

The climate at the site is essentially continental in nature and is characterized by moderate extremes of temperature and precipitation. Summers are moderately warm and humid with occasional days when temperatures exceed 100°F; winters are reasonably cold with an average of about 2 days of sub-zero weather. The mean annual precipitation of 44.02 inches is moderately well distributed with peaks in early spring and summer. Mean annual pan evaporation ranges between 40 and 45 inches per year (U.S. Department of Commerce, 1968) with greatest evaporation occurring during June and July. A monthly summary of average temperature, precipitation, and evaporation near Hannibal, Ohio, is presented in Table 4.

GEOLOGY

General

The Ormet plant is located on Buck Hill Bottom, a broad alluvial terrace along the west bank of the Ohio River between river miles 122 and 125.

At this location, the alluvial terrace is about 4 miles long, about one-half mile wide at the widest point, and pinches out against the bedrock valley wall at both ends.

Underlying the alluvial terrace are bedrock formations made up of shales, sandstones, and coals of Permian age. These formations are relatively impermeable and do not constitute an important aquifer.

Overlying the bedrock are unconsolidated deposits of recent alluvium and glacial valley train deposits. These deposits consist of sands and gravels with some interbedded clays and silts. The sands and gravels are relatively permeable and constitute the principal ground water aquifer. The silts and clays are relatively impermeable and retard or act as barriers to the ground water flow.

Site Geology

Subsurface information furnished by Ormet Corporation indicates that the geologic conditions at the site are typical of the general area. Figures 2 and 3 are geologic cross sections showing the subsurface conditions beneath and near the site. Logs of borings drilled in the Ohio River by Klaer and Associates (1972) indicate the bedrock elevation beneath the river is approximately 555 to 560 feet msl near Ranney Well No. 1. Northwest of there, the bedrock elevation increases to 602 feet msl at Test Hole 11 (TH-11) and approximately 700 feet msl near State Route 7.

Overlying the bedrock are fluvial-glacial sands and gravels. These sands and gravels, which are absent 940 feet south of Ranney Well No. 1, thicken to the north and obtain a maximum thickness of approximately 80 to 100 feet beneath the Ormet plant. Cross section A-A (Figure 2) illustrates the thickening sands and gravels and the thick wedge of silts and clays near the Ohio River. This thick wedge of fine material was present in Borings RTH-3, RTH-8, RTH-9, TH-1, TH-4, TH-8, and TH-9, all located near the Ohio River. Because of the river meandering near Ormet, the lowest river velocity is along the northern bank (Ohio side) of the Ohio River and the highest velocities are located along the West Virginia side of the Ohio River. The difference in velocities causes deposition of silts and clays on the northern bank of the Ohio River and was probably responsible for a wedge of low permeability material as shown in the north-south cross section (Figure 2). This figure also shows permeable sand and gravel near the ground surface at Borings TH-6 and TH-10. Outcrop of the permeable materials provide a possible means for leachate to migrate from the surface to the ground water.

Cross section B-B (Figure 3) shows about 20 feet of relatively clean sand and gravels near the Ranney well to the east-northeast. These sands and gravels, locally thin, thicken towards the Ohio River channel because of the thickening of overlying silts and clays near the river. Although not differentiated in the sections, surface fill has been placed on the southern half of the site. In the gully at outfall no. 4 the overlying low permeability materials appear to have been eroded, thus possibly exposing the underlying aquifer.

The average permeability of the sand and gravels is estimated at about 2000 gallons per day per square foot (gpd/ft^2)(Klaer, 1972), or 9.4 x 10^{-2} cm/sec. However, increased percentages of silts and clays such as found near the Ohio River decrease the permeabilities of the sand and gravel. Permeability of silts and clays usually range between 0.2 to 0.002 gpd/ft^2 (10^{-5} to 10^{-7} cm/sec).

HYDROLOGY

General

Ground water from sand and gravel aquifers along the Ohio River, such as those near Hannibal, Ohio, are used primarily for industrial, municipal, and domestic water supplies. The nearest municipal ground water users are Clarington, Ohio, and New Martinsville, West Virginia. Clarington, located approximately 8 miles upstream of Ormet, utilized 0.50 mgd in 1969 (Ohio Department of Health, 1969), while New Martinsville, located approximately 3 miles downstream from Ormet, uses approximately 1.4 to 2.0 mgd. Major industrial ground water withdrawals near Hannibal, Ohio are primarily from the two Ranney wells owned by Ormet and Conalco and range from 6 to 7 million gallons per day (mgd).

Prior to the construction and operation of these wells, the natural ground water gradient sloped from the valley wall toward the Ohio River. The sand and gravel aquifer was recharged from rainfall falling on the alluvial terrace, from leakage from the bedrock, and from the Ohio River during periods of high river stage. During these high stage periods, natural ground water gradients were locally reversed and the ground water table was recharged by the rise until the river stage receded.

Site Hydrology

In 1956, Ranney Wells No. 1 and No. 2 were constructed for Ormet Corporation and Conalco, respectively. These wells had a combined capacity of about 10 million gallons per day. Aquifer tests made prior to their construction indicated that the coefficient of transmissibility (product of the permeability and the saturated thickness) was moderately high and that infiltration from the Ohio River could be induced within relatively short distances from the centers of pumpage.

When pumping of the Ranney wells commenced, the water levels around each Ranney well declined in the shape of an inverted cone. The shape of this cone of depression is controlled by the rate of pumping, the permeability and thickness of the aquifer, and the infiltration rate through the river bottom. At first, the development of the cone of depression was symmetrical, but as the cone of depression extended under the river, infiltration was induced and the ground water gradients became steeper near the river; conversely, on the land side, the ground water gradients became flatter. This extended the effects of pumping landward to the limits of the aquifer, the bedrock wall of the valley.

The rate of infiltration through the river bed appears to be lower than had originally been estimated. This is probably a result of the presence of the thick wedge of relatively impermeable clays and silts found along the northern bank of the Ohio River, the rapid thinning of the sand and gravel aquifer beneath the West Virginia side of the Ohio River, and the low permeable bottom of the Ohio River. Because of reduced recharge available from the Ohio River, the cone of depression increased in size, extending both upstream and downstream until it stabilized. In 1966, test drilling in the river showed the ground water levels were below river level about 2200 feet upstream from the Ormet Ranney well. This indicates that river sediments are restricting the movement of water from the river into the aquifer.

Present ground water levels, shown on Figure 4, indicate that the center of the cone of depression around Ranney Well No. 1 is approximately 32 feet below the current river pool. The cone of depression appears to have increased since 1966, extending out past the disposal pond, approximately 3500 to 4000 feet east-northeast of the Ranney well. Any recharge within the cone of depression, including contaminates from the disposal pond or the waste pot lining storage area, would migrate down-gradient toward Ranney Well No. 1.

Normal ground water recharge rates for precipitation falling on alluvial deposits along the Ohio River range between 0.2 to 0.5 mgd per square mile of surface area (Whitesides, 1969). Assuming the site area (Buck Hill Bottom) contains approximately 2 square miles of alluvial terrace, then recharge from precipitation would contribute approximately 0.4 to 1.0 mgd. Because Ormet's and Conalco's wells currently withdraw about 6 mgd, the balance of the ground water is obtained through induced recharge from the Ohio River or from man-made sources.

Increases in river stage above normal pool stage are reflected in ground water level rises which indicates there is some hydraulic connection between the aquifer and the river. However, decreases in the amount of water produced by Ranney Well No. 1 may indicate either the laterals are encrusted or that silting along the river bottom has reduced the hydraulic continuity. Although most of the water pumped by Ranney Well No. 1 is from induced infiltration from the river, the proportion of the water from the river has decreased somewhat. This has resulted in a proportionate increase in water withdrawn from the landward side and in increases in concentrations of contaminates. To control these changes in water quality, interceptor wells have been pumped at higher rates.

A potentiometric map made in 1972 by F.H. Klaer, Jr., and Associates shows the water level elevation beneath sludge disposal pond No. 5 to be at about 607 feet and near TH-3 to be about 595. Water level measurements in July 1977 indicated a water level elevation of about 620 feet beneath sludge disposal pond No. 5 and 609 feet near TH-3. This rise in water levels is largely in response to increased stage of the Ohio River because of the Corps of Engineers raising the pool elevation. It is interesting to note that the ground water gradient on the landward side in 1972 is almost the same as the gradient in 1977.

RESULTS OF INVESTIGATION

SOURCE OF CONTAMINATION

An evaluation of existing data, along with site reconnaissance, indicates that there are three probable sources of contamination. These sources are:

1. sludge disposal ponds
2. the waste pot lining storage area
3. fugitive waste areas
   a. outfalls
   b. pot shell storage areas

Sludge Disposal Ponds

The sludge disposal ponds are probably a major source of ground water contamination. Sludge disposal pond No. 5, which has been operational since 1967, is known to have leaked. Prior to June 1977, untreated wastes from the cryolite plant discharged into this pond. Since June, the cryolite plant wastes have been treated in the neutralization plant before being discharged into the pond.

Slurried wastes were discharged into waste disposal pond No. 5 at a rate of approximately 65 to 100 gpm from 1967 to April 1977. During that time, the surface water covered only about 20 percent of the total pond surface, and the pond had no outlet for excess liquid although it seldom overtopped its embankments. It is estimated that there could have been up to about 80 gpm of pond seepage for this period (assuming 44 inches precipitation over the entire pond and 42 inches evaporation over 20 percent of the water surface and 20 percent solids by weight in the slurry). It is suspected that some of this leachate seeped from the north side of the sludge pond where permeable sands and gravels immediately underlie the pond. This leachate probably migrated into the ground water and was subsequently drawn toward the Ranney well.

Since April 1977 the volume of slurry discharge has increased to 250 gpm, the pond surface is covered, and a decant line has been installed to remove excess water to the gully above outfall no. 4. Because of increased water surface and water surface elevation, the theoretical potential for seepage has increased. However, because of the volume of water involved and the relatively small volume of seepage that may be occurring, accurate inflow-outflow measurements are difficult to make.

The four abandoned sludge disposal ponds probably contribute minor amounts of contaminates to the ground water. These contaminates are possibly leached by rainfall percolating through the exposed sludge. Because the leachate production in these ponds is dependent on the unknown volume of soluble contaminates still present and the unknown percolation rate through the sludge, the rate of leachate production cannot be accurately calculated.

Waste Pot Lining Storage Area

The waste pot lining storage area located north of sludge pond 5 also appears to be a potential contributor to the contamination of Ranney Well No. 1. Fluoride concentrations in waste pot lining material decrease from approximately 15 percent to 6 percent during open storage. Rainfall falling on this area migrates through the waste pot lining and percolates down to the ground water table. The leachate would likely have a high pH and would contain both fluoride and cyanide. Earlier reports by Klaer and Associates (September, 1972) indicated leachate from the waste pot lining had contaminated the ground water sampled from Boring TH-14A. The amount of leachate from this source cannot be accurately calculated since the rate of chemical release from the waste pot liners is unknown.

Fugitive Waste Areas

The outfalls which discharge water to the Ohio River may contribute small amounts of fluoride to the ground water by direct infiltration through the soil. This is particularly true at Outfall 4 where the effluent from the sludge pond flows into an unlined drainage ditch. This unlined ditch could allow unknown quantities of contaminates to percolate to the ground water. The outfall effluent quality and quantities are shown on Table 3.

The open storage in the plant itself of spent pot shells containing small amounts of pot lining material may contribute contaminates to the ground water regime through runoff and percolation. The amount of leachate produced by these spent shells cannot be determined, but it is thought to be relatively insignificant in comparison to other sources.

LEACHATE QUALITY

An estimate of the quality of leachate generated from the disposal pond and the waste pot liner area is presented in Table 2. Leachate quality for outfalls, presented in Table 3, are for two sample periods after treatment began and probably do not reflect the full range of chemical concentrations.

Because of dependency on rainfall for leachate production in the abandoned ponds and stored waste pot linings, leachate quality can only be approximated.

Routine analysis of the pond effluent is performed for fluoride, pH, and color. Not reported is the organic content which increases the color and reduces the percent of light transmittance. Ormet Corporation chemists report that, based on laboratory tests, leachate produced from effluent having a pH of 8.9 or higher would likely react with natural earth materials, particularly organic or humic materials, to increase the water color.

EXTENT OF CONTAMINATION

Water samples for analyses were collected from test holes wells during February 16-18, 1972, by F.H. Klaer and Associates. The results of these analyses were used in this study to depict the areal extent of fluoride concentration as shown on Figure 4. This figure shows the highest fluoride concentrations, about 900 mg/l near test wells TH-5 and TH-6 with concentrations decreasing down gradient. It is suspected that present fluoride concentrations along a narrow flow path or band near the interceptor wells may range from 220 to 340 mg/l. This will be discussed later.

Vertical changes in fluoride concentrations in the aquifer were not analyzed in previous collected soil and water samples. However, it is likely that fluoride concentrations decrease with depth. This is because the concentrations near the source of the fluoride are likely to be higher than samples from the test wells which tap the basal portion of the sand and gravel aquifer. This may explain some of the water quality variation that F.H. Klaer found during their sampling of test wells in early 1972. Some downconing of poorer quality water may have occurred as a function of time and rate of pumping.

MOVEMENT OF CONTAMINATES

After leachate has been generated in source areas it would percolate downward to the ground water table. The rate of leachate movement through the unsaturated soil varies according to the amount and duration of precipitation, the antecedent soil moisture conditions, and the permeability of the soils. Once in the ground water, the leachate would migrate down gradient. During this movement, the concentration of contaminates in the leachate would decrease down gradient and laterally from the point of entry into the ground water table. The reduction in fluoride concentrations with distance from the point of entry is due to the dispersion and dilution of the contaminates.

The pumping of Ormet's Ranney Well No. 1 creates a cone of depression into which water migrates. Any leachate entering the ground water table within the influence of the Ranney well would likely be drawn toward the well.

The rate of ground water movement was calculated using the water level contour map, Figure 5, and a modified version of Darcy's Law:

$$v = ki/n_e$$

where

v = the average ground water velocity
k = the permeability of the aquifer
i = the hydraulic gradient (from the map)
n_e = the effective porosity

Assuming an effective porosity of 0.15, an average permeability of 2000 gpd/ft^2 (Klaer, 1966), and a gradient of 0.0074 ft/ft, a typical ground water velocity from the center of the sludge disposal pond and the waste pot lining storage area to the Ranney well was calculated to be approximately 13 ft/day. This indicates that recharge water from precipitation percolating to the ground water from the area near the pot liner storage area or the sludge disposal pond would take about 250 to 300 days to reach the Ranney well. It must be emphasized that contaminates in the ground water probably migrate at a much slower rate than the ground water. This is because of retardation of the contaminates by physical and chemical attractive forces. Some ions or molecules may never migrate to the ultimate point of ground water discharge because they may be effectively removed from solution by adsorption, cation exchange, or chemical precipitation.

It is not possible to precisely estimate how long it would take to flush the contaminates from the aquifer without more time-dependent data.

The potentiometric map shown on Figure 5 was analyzed using flow net or flow line concepts. The flow lines are perpendicular to the lines of equal ground water elevation and represent the path a particle of water would take. The distance between adjacent flow lines is adjusted so that a "square" is formed with the adjacent ground water contours. That is, the sum of the length of adjacent flow lines between 2 adjacent ground water contours is equal to the sum of the length of the 2 adjacent ground water contours between the flow lines. The quantity of ground water flowing through any square is equal to that flowing through any other square. This assumes that the aquifer is homogeneous and isotropic. Although this aquifer system does not quite meet these conditions, the error so introduced into the analyses by that assumption is probably not appreciable. It was found that there are 21 flow paths or squares surrounding the cone of depression formed by pumping the interceptor wells at 500 gpm and the Ranney well at 1350 gpm. Therefore, each flow path is equivalent to about 90 gpm contribution to the cone of depression. Because the flow paths diverge with distance from the center of pumping, 1 to 1-1/2 flow paths cover the entire area of suspected ground water contamination. This means that about 100 to 150 gpm of ground water flows through the area of the source of contaminates. Thus, the contamination is transported by about this quantity of water.

If a mass balance is applied to the present fluoride concentrations, it is estimated that the concentration of fluorides in the ground water along the contaminated flow path is 220 to 340 mg/l.

FLUCTUATION OF LEVELS OF CONTAMINATION

The amount of contamination reaching the Ranney well varies due to changes in:

1. the leachate production rate,
2. the stage of the Ohio River, and
3. the pumping rate of the Ranney and interceptor wells.

Leachate Production Rate

The leachate production rate from the abandoned sludge disposal ponds and the waste pot storage varies due to frequency and duration of precipitation, evaporation, and soil moisture conditions. Frequent, heavy precipitation (usually experienced during the spring and fall) potentially flushes greater quantities of contaminates into the aquifer than during drought conditions. The lowest rate of leachate production would occur during the late summer when evaporation is the greatest and precipitation is the lowest. During the winter months, recharge to the aquifer decreases because of the low permeability of frozen sludges and soil, and little available water due to unmelted snowfall. This was probably true during the severe winter of 1977. The rate of leachate production from waste disposal pond No. 5 is expected to be nearly constant because of its constant head of water. Figure 6 shows the concentrations of fluoride in water from the Ranney well and the interceptor wells. There is an inference that the concentrations of fluoride are higher from February through May. This could be the result of a time lag from high precipitation periods of the previous year.

Stage of the Ohio River

Fluctuation in the Ohio River stage affects ground water gradients, which in turn alters the rate of induced recharge to the aquifer. Because of the pumping of the Ranney well the natural ground water gradients have been locally reversed. The majority of water pumped from the Ranney well is obtained through induced recharge from the Ohio River. Increases in river stage temporarily create steeper hydraulic gradients from the river and allow greater quantities of river water to enter the aquifer through induced recharge. During low river stage there is less induced recharge, and less dilution of contaminated ground water. Generally the highest river stages are observed during the spring of the year, with lowest stages observed in September and October. It is believed that some silt layers on the river bottom prevent the full inducement of the river water to the Ranney well. The recent pool level increase has probably increased the rate of silting. Thus changes in river stage may have indirectly caused a subtle change in ground water quality.

Pumping Rates of the Ranney and Interceptor Wells

Because of increased production, water requirements of Ormet's plant have increased since 1957. Initial quantities of water produced by Ormet's Ranney well were sufficient for the plant's sanitary and process requirements. Increases in ground water withdrawals and decreases in the contribution from the river has created additional water level declines and a larger area of influence. This likely has resulted in a larger percentage of contaminates being drawn toward the Ranney and interceptor wells.

SUMMARY AND CONCLUSION

GENERAL

The contamination of the ground water with high concentrations of fluoride, cyanide, and organics and high pH and color, is the result of waste disposal or storage practices upgradient of the Ranney well. The source of ground water contamination is believed to be mainly from the sludge ponds, the number 4 outfall, and the waste pot lining storage area. However, there are not sufficient data to quantify these suspected source areas. The possible contamination from outfall 4 is by direct percolation of effluent. The other sources of contamination are mainly from the generation of leachate by solution of contaminates by precipitation and from the effluent itself. The leachate is caustic, has a high pH and contains high concentrations of fluoride. Some cyanide is also produced. If the effluent and the leachate are caustic and above pH of 8.9, Ormet Corporation reports organics would be leached from the soil which would cause increased color to ground water.

It is likely that some of the contaminates enter the ground water aquifer along the north side of the No. 5 sludge disposal pond. There may be some contribution from old abandoned and filled sludge ponds. Soil borings by Klaer and Associates indicate that shallow permeable sand and gravels near the sludge ponds and pot lining storage area would provide a path for leachate percolation to the water table. Once in the ground water, the contaminates migrate downgradient toward the Ranney and interceptor wells. The ground water takes about 250 to 300 days to migrate from the suspected contaminate source area to the interceptor wells. However, the contaminates would be retarded and move more slowly with dilution and dispersion decreasing the concentrations of the contaminates. Most of the contaminated ground water is captured by the interceptor wells and does not reach the Ranney well.

IMPACT

Data indicate that the contamination of the Ranney well will continue as long as leachates are produced in the sludge ponds, the waste pot lining storage area, and from the suspected percolation of effluent from Outfall No. 4. Natural flushing of the aquifer is not expected to reduce contamination levels until leachate production is eliminated or substantially reduced. Some reduction in contamination levels may occur since wastes from the cryolite plant are being neutralized and the stockpile of stored pot linings is steadily being depleted. However, continued pumping of the interceptor wells will be necessary to protect the Ranney well until residual contamination is removed.

Concentrations of fluoride have been found in the ground water at Ormet as much as 500 times greater than the Public Health Department Drinking Water Standards of 0.7 to 1.2 mg/l. National limits for cyanide of 0.01 mg/l have also been exceeded (Standard Methods, 1971). Sanitary water presently used at Ormet (from Conalco's Ranney Well No. 2) meets Public Health Department Drinking Water Standards.

The pumping of the interceptor wells to remove contaminates reduces the quantity of water available for use at Ormet. It is believed that yields from Ranney Well No. 1 should not decrease appreciably over the next few years. Tentative planned future reductions in water needs at Ormet by as much as 50 percent should improve the water supply situation from a quantitative standpoint. However, until the reduced consumptive water use by Ormet is instituted, process water demands must be supplemented from Conalco. The interceptor wells and the Ranney wells should continue to be used, as long as contamination is evident and regardless of Ormet's water needs, to safeguard the quality of ground water used by Conalco.

INVESTIGATIVE PROGRAM

The reports from studies conducted by Fred H. Klaer, Jr., & Associates were very useful and contained meaningful data and conclusions. Unfortunately, little data have been collected since early 1973. It is strongly recommended that a monitoring and investigative program be instituted prior to commencing any remedial measures. This is because the existing data base is not complete enough for other than a general evaluation and not sufficient to formulate detailed methods and plans, and to make an assessment of success of remedial measures. So more complete and current data should be obtained to more accurately identify, formulate, and assess remedial plans.

To allow for maximum flow of the most pertinent data early in the investigative program, it is recommended that a phased program be adopted. This phased program would be cost effective inasmuch as some work items of later phases may not prove necessary.

PHASE I

1. Measure the water levels in all wells prior to collecting water samples as a means of assessing ground water gradients in response to pumping, precipitation, and river stage. This data would be used to determine rate and direction of ground water movement.

    a. Measurement should be made using a steel tape and chalk or an electric water level tape.

    b. Subsequent monthly measurements should be made and the data should be tabulated for each well and a hydrograph kept current showing rainfall, river stage, and pumping rates of the interceptor wells and the Ranney well.

    c. Annually, all wells at Ormet and Conalco should be measured and a potentiometric map constructed to show ground water flow patterns and distribution of recharge and discharge areas.

2. Collect water samples from all monitoring wells as a means of identifying source and extent of ground water contamination.

   a. The wells should be pumped a sufficient time to empty at least twice the volume of the water contained in the casing before the sample is collected. Samples should also be collected every 30 minutes for a period of 2 hours to establish the optimum sampling time after pumping begins.

   b. The water samples should be analyzed for fluoride, cyanide, ammonia, total dissolved solids, hardness, chlorides, color, and pH.

   c. Water samples of runoff and from puddled water and seeps throughout the waste sites should also be collected.

   d. All analyses should be tabulated and used for constructing maps and cross sections of the water quality data.

   e. Subsequent monthly water samples should be collected and analyzed and the data for each well should be tabulated and graphs kept current.

   f. An annual water sample should be collected and analyzed for the above constituents or parameters plus calcium, magnesium, manganese, iron, sodium, potassium, alkalinity, total organic carbon, and phenols.

3. Four or five percolation tests should be made in each of the 5 waste disposal ponds, in the waste pot storage areas, and along the bottom of the gully along Outfall No. 4 to determine the in-situ permeability of the materials as a means of assessing the potential for infiltration of leachate.

4. Samples of shallow soil and waste sludge should be collected during the digging of holes for the above percolation tests and by hand augering to depths of about 8 to 12 feet and used for particle-size analyses, consolidation and unconfined shear tests, and Atterberg limits, chemical analyses, and leachate column testing. This information will assist in determining the chemical and physical properties of the materials and in assessing the potential adsorption and release of contaminates from the materials as leachate.

   a. Chemical analyses would include cyanide, fluoride, and ammonia.

b. The column tests would subject samples of soil or waste sludge to percolating distilled water. Samples of the resulting leachate and the leached soil or waste would be analyzed for cyanide, fluoride, ammonia, TOC, color, and pH as appropriate.

c. The strength tests will be used to evaluate the physical properties of the sludge and to determine the feasibility of using the abandoned sludge ponds for other purposes such as open material storage or parking lots.

5. Conduct a reconnaissance of nearby sources of clay borrow material for liner and cover material. Surface samples should be obtained for visual inspection.

6. Compile and evaluate the results of Phase I field and laboratory studies to determine if remedial alternatives can be formulated and assessed or if all or part of the Phase II investigation would need to be performed.

PHASE II

1. Drill borings at about 10 locations and install one or more screened monitoring wells at each site. These prospective sites are tentatively shown on Figure 7. The drilling is necessary because some of the test wells previously drilled have been destroyed, or are not available for monitoring and need to be replaced. Data are needed at other locations not presently being monitored. The borings will also permit a much better definition of geologic materials than previous borings. The exact location of the borings would depend, in part, on the results of Phase I.

   a. Individual monitoring wells should be constructed with screens gravel packed and casings grouted so as to tap the aquifer at different levels. This would establish vertical distribution of contaminates and different head potentials.

   b. Perform laboratory permeability tests of low permeability materials overlying the aquifers to assess percolation rates at intermediate depths.

   c. Include new monitoring wells in monitoring program (Items 1 and 2, Phase I).

2. Install equipment and monitor daily inflow of slurry and outflow of effluent from waste pond No. 5. This data would be used to assess the leakage from the pond.

3. Investigate vertical and lateral extent and properties of nearby clay sources to be used as cover or liner material of present or future waste sludge disposal sites.

   a. Drill about 10 borings from 15 to 30 feet deep and collect soil samples for laboratory testing.

   b. Laboratory testing of about 10 samples for consolidation and permeability properties.

4. Evaluate the above generated information and data, including incorporation of results of Phase I data collection program, to identify and quantify to the extent possible the sources of ground water contamination. The investigation could possibly include analyzing the data using a digital computer model to simulate the ground water flow system.

PHASE III

Evaluate the technical and economic feasibility of mitigating alternatives and formulate general recommendations and conceptual plans. This would be done after the evaluation of the geohydrologic system and the extent of contamination has been performed.

INVESTIGATIVE PROGRAM COSTS

The costs for conducting the Phase I and Phase II investigative programs are based on Dames & Moore and their subcontractors performing all of the outlined work. It is assumed that Ormet Corporation personnel will be unavailable to perform any field or laboratory tasks. This assumption increases the cost of certain work items appreciably, especially those items pertaining to collection and analyses of water samples. The costs are as follows:

PHASE I	- Item 1	$ 2,800
	Item 2	22,000
	Item 3	2,800
	Item 4	11,000
	Item 5	800
	Item 6	4,500
	TOTAL	$49,900
PHASE II	- Item 1	$54,500
	Item 2	5,500
	Item 3	6,000
	Item 4	13,500
	TOTAL	$79,500

These estimated costs are on a time and expense basis and include costs for drilling, laboratory testing, travel, subsistence, and equipment. Because of many uncertainties, professional service for Phase III cannot be accurately estimated at this time but is believed to range from $12,000 to $15,000.

ALTERNATIVES TO MITIGATE CONTAMINATION

As previously stated, the contamination of the Ranney well will continue as long as leachate is produced in the sludge ponds, the waste pot lining storage area, and from the suspected percolation of effluent from Outfall No. 4. It is recommended that mitigating measures to eliminate contamination of the ground water supply eventually be implemented. The investigative program should first be accomplished and analyzed before formulating mitigating actions. However, it is believed that some of the possible mitigating actions may be as described in the following paragraphs.

STABILIZATION OF THE WASTES

Wastes presently in the waste disposal ponds could likely be stabilized by either covering with clay cover or by encapsulation to prevent leaching of contaminants by precipitation.

Clay Cover

A minimum of 2 feet of compacted clay cover placed over abandoned ponds would substantially reduce rainfall percolating through the landfill and subsequent leachate generation. This cover should probably be placed in 6-inch lifts with each successive lift placed perpendicular to the preceding one. Extreme rises in river stage could possibly saturate the bottom portions of the sludge, causing some release of contaminants. It is likely a clay cover should be installed over the pot lining storage area also. Grading of the sludge and the pot lining storage area surfaces should precede installing the cover to prevent surface water ponding.

Encapsulation or Lining of Sludge Ponds

Contaminates in the waste disposal ponds could be contained by using either an impermeable, nonreactive membrane or compacted clay to eliminate seepage of leachates to the sand and gravel aquifer. The purpose of encapsulation is to seal the bottom and to ultimately limit leaching of the soluble wastes by physically keeping rainwater from contacting the wastes. Ideally, the impermeable material should completely encapsulate the chemical wastes to minimize leaching.

Encapsulating landfills is technically feasible and is viewed favorably by regulatory agencies. It is, however, somewhat questionable if the regulatory agencies would permit a new landfill using this technology at this site; however, mitigating an existing landfill would probably be acceptable. This is mainly because regulatory agencies are striving to locate disposal sites on relatively impermeable soils and not over gravels and sands associated with river sediments.

CHEMICALLY NEUTRALIZE SLUDGE

There is a reasonable possibility that the largely untreated sludge in the 5 sludge disposal ponds could be chemically neutralized to reasonably acceptable levels. Considerable testing would be necessary to identify the extent and properties of the sludge and to formulate an optimum neutralization method. The neutralization could be done in-situ with or without mixing chemical additives with the sludge. Depending upon the type and amount of chemical additives and the need for mixing, neutralization could range in cost from moderate to very expensive.

EXCAVATION AND REMOVAL OF EXISTING WASTES

The chemical and physical wastes present in the sludge disposal ponds and the waste pot storage area could, if proven to be unmanageable by other means, be removed and disposed of in properly constructed landfills not adjacent to permeable materials along the Ohio River. This would involve the acquisition of property under which the soil material was relatively impermeable and on which recharge was limited.

The removal of waste and subsequent deposition in a certified waste landfill would probably be the most acceptable alternative to the regulatory agencies. There would likely be appreciable environmental disturbance during the excavation which could result in abnormally high quantities and concentrations of slugs of leachate reaching the ground water system. This alternative would also be very costly.

INTERCEPTOR WELLS

About four interceptor wells could be installed in a north-south line south and west of Test Hole 11 to capture any leachates migrating from the sludge ponds and waste pot storage area toward the Ranney well. The discharge from the interceptor wells should be treated to reduce the level of contamination. The method has an advantage of an attractive first or capital cost and would likely be quite efficient. Its disadvantage is that it would require a moderate continuing maintenance and operating cost, would require the construction of a water treatment facility, and the method treats the effect but not the cause of contamination.

Another modification of the interceptor concept is to pump the 8-inch well at about 100 to 200 gpm and discharge the water into the neutralization plant, thence to sludge pond No. 5. It is believed that pumping there could intercept much of the leachate-contaminated ground water. Until more is understood about the source(s) and mechanism of contamination, an evaluation of the effectiveness of the pumping is not possible. It is believed, however, that about 100 to 150 gpm of contaminated ground water is migrating from the area near the 8-inch well to the interceptor well.

RECHARGE BARRIER

A recharge barrier would create a hydraulic barrier to most of the contaminate migration towards the Ranney well. By increasing the ground water levels in the gully near Outfall 4, the hydraulic gradients would be reversed causing contaminates to largely migrate to the Ohio River. The barrier could likely be formed by recharging river water through pits or ditches.

This method would not reduce local aquifer contamination beneath the sludge disposal ponds or the waste pot storage area but would isolate most of the leachates from the Ranney well. It cannot be accurately determined at this time if some bypass leakage would occur. This method would require a moderate first cost and moderate maintenance and operating costs.

STRUCTURAL BARRIER

Leachate migrating from the waste disposal areas could possibly be prevented from moving downgradient to local pumping centers by constructing a grout curtain, a slurry wall, or driving sheet piles down to bedrock along a north-south line from TH-11. The slurry trench method would involve excavating a deep narrow trench through the sand and gravel aquifer and backfilling the trench with a low permeability slurry such as bentonite mud. These trenches would range in depth from 60 to 100 feet at the landfill site.

A grout curtain is another possible method of reducing the permeability of the aquifer around the perimeter of the landfill. Grouting methods involve drilling a line of small diameter holes into the permeable zones of the aquifer. Grout, either cement or chemical, is injected under pressure into the permeable sands and gravels forming a "wall" of very low permeability materials around the landfill. Steel pilings could be driven from the ground surface to bedrock to form an impermeable barrier to leachate migration.

The grout curtain and piles probably have only moderate acceptance possibilities by regulatory agencies because of the uncertainties of completely isolating the subsurface beneath the landfill. There may also be problems with reactions between the chemical grout and the leachate. The slurry trench concept is believed to have a moderate acceptance potential with regulatory agencies. These methods would have an extremely high first cost but low operating cost.

OUTFALL CONTROL

It is believed that outfall No. 4 carrying effluent from waste disposal pond No. 5 should be piped to the river and not permitted to possibly percolate into the aquifer. This could be an effective low cost means of

SUGGESTED PROGRAM

The following suggested program is listed in order of its priority (the highest priority item listed first) for consideration.

1. Implement Phase I Investigative Program.

2. The Ranney well laterals should be inspected to determine if incrustations have reduced infiltration. The Ranney well company stated that they commonly send a diver into the Ranney well to inspect the installation and to measure the velocity of flow from each lateral. If incrustation of the laterals is suspected, mechanical or mechanical and chemical treatment and cleaning would likely be beneficial. Normally the well is out of production for 36 to 48 hours at a minimum.

3. Continue the rate of removal of the remaining stored waste pot linings or move the waste pot linings to a covered and floored storage area. Fugitive in-plant wastes which could be a source of ground water contamination should be stored in covered areas where rainfall cannot generate leachate.

4. Complete Phase I Investigative Program and evaluate if Phase II is required or if sufficient information is available to formulate alternatives to mitigate ground water contamination. If Phase I is sufficient, formulate these alternatives. If Phase I is not sufficient, implement Phase II.

5. Outfall 4 effluent should discharge to the Ohio River via pipeline or asphalt line ditch. This would reduce possible percolation into the water table. This should be done only after the Phase I Investigative Program has been completed. Agency requirements for point discharge must be considered.

6. Encapsulate any future waste disposal ponds and place a clay cap over the abandoned waste disposal ponds to reduce leachate production. This should be done only after the results of Phase I and/or Phase II Investigative Program(s) indicates such measures are effective and needed.

reducing potential contamination from that source. It is assumed that the cognizant regulatory agencies are aware and in agreement with the present outfall discharge to the Ohio River.

RELOCATION OF WATER WELLS

New water supply wells could probably be drilled east of the sludge disposal pond near Test Hole 12. This area would probably have potential production rates similar to the area at Ranney well No. 1. However, the resultant withdrawals would probably reverse existing ground water gradients causing contaminants to migrate toward the new wells. Until the source of contamination is eliminated or reduced, large scale pumping in this area is not encouraged. It is probable, however, that 500 or 600 gpm of water for sanitary purposes could be developed, although more data and analyses would be necessary to more precisely predict the success of such a facility.

SUGGESTED ALTERNATIVES

It is recommended that an investigative program be conducted to assess the source and controls of ground water contamination before any significant remedial efforts are made. However, based on our evaluation of the limited data and information at hand, it is our opinion that the lining of any future operating sludge disposal pond (and eventual cover), a clay cover over the abandoned ponds, and piping of effluent from outfall No. 4, may be the most favorable alternatives to alleviate ground water contamination. Construction of the above alternatives would not eliminate the use of the present interceptor wells until the residual contamination in the aquifer has diminished to acceptable levels.

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TABLE 1

PROCESS WATER USAGE AT ORMET CORPORATION HANNIBAL PLANT

	Max. Des. Flow	Measured 9/10/68
Rectifiers, Potlines 1 - 5	1800 GPM	1280 GPM
Rectifiers, Potline 6	700	500
Rod Room	210	80
Anode Presses	50	40
Green Mill	60	50
Steam Make-up	70	50
I.R. Air Compressors	240	130
Elliott Air Compressors	150	110
Carbon Baking		50
Cryolite Recovery	150	110
	3430 GPM	2400 GPM

Reference: Ormet, 1974.

TABLE 2

ESTIMATED LEACHATE QUALITY PROVIDED BY THE SLUDGE DISPOSAL POND AND THE WASTE LINER STORAGE AREA

Disposal Area	Parameter Measured	Average Range of Parameter
Sludge Disposal Pond* (prior to neutralization plant)	pH	10.5-10.7
	Fluoride (ppm)	1,100-1,400
	Transmittance	0
	Cyanide	trace
Sludge Disposal Pond** (after neutralization plant)	pH	6.5-7.5
	Fluoride (ppm)	19-400
	Transmittance	unknown
	Cyanide	0
Waste Pot Lining Storage	pH	10
	Fluoride (ppm)	unknown
	Cyanide (ppm)	trace
	Transmittance	unknown

*Leachate value for all sludge disposal ponds.

**Leachate value for presently operating sludge pond since May, 1977.

TABLE 3

OUTFALL FLOW RATES AND CHEMICAL ANALYSIS

July 7, 1977 Sample

Outfall	1	2	3	4
Total suspended solids (ppm)	16	62	169	97
Fluoride (ppm)	14	44.3	66.8	23.8
Flow (MGD)	1.09	0.62	0.06	1.21
Temperature (°C)	28	39	28	28
pH	7.3	6.7	8.5	6.8

July 21, 1977 Sample

Outfall	1	2	3	4
Total suspended solids (ppm)	84	12	919	29
Fluoride (ppm)	24	20	151	44
Flow (MGD)	1.19	1.07	0.10	1.39
Temperature (°C)	29	41	24	27
pH	7.2	7.4	6.0	7.2

TABLE 4

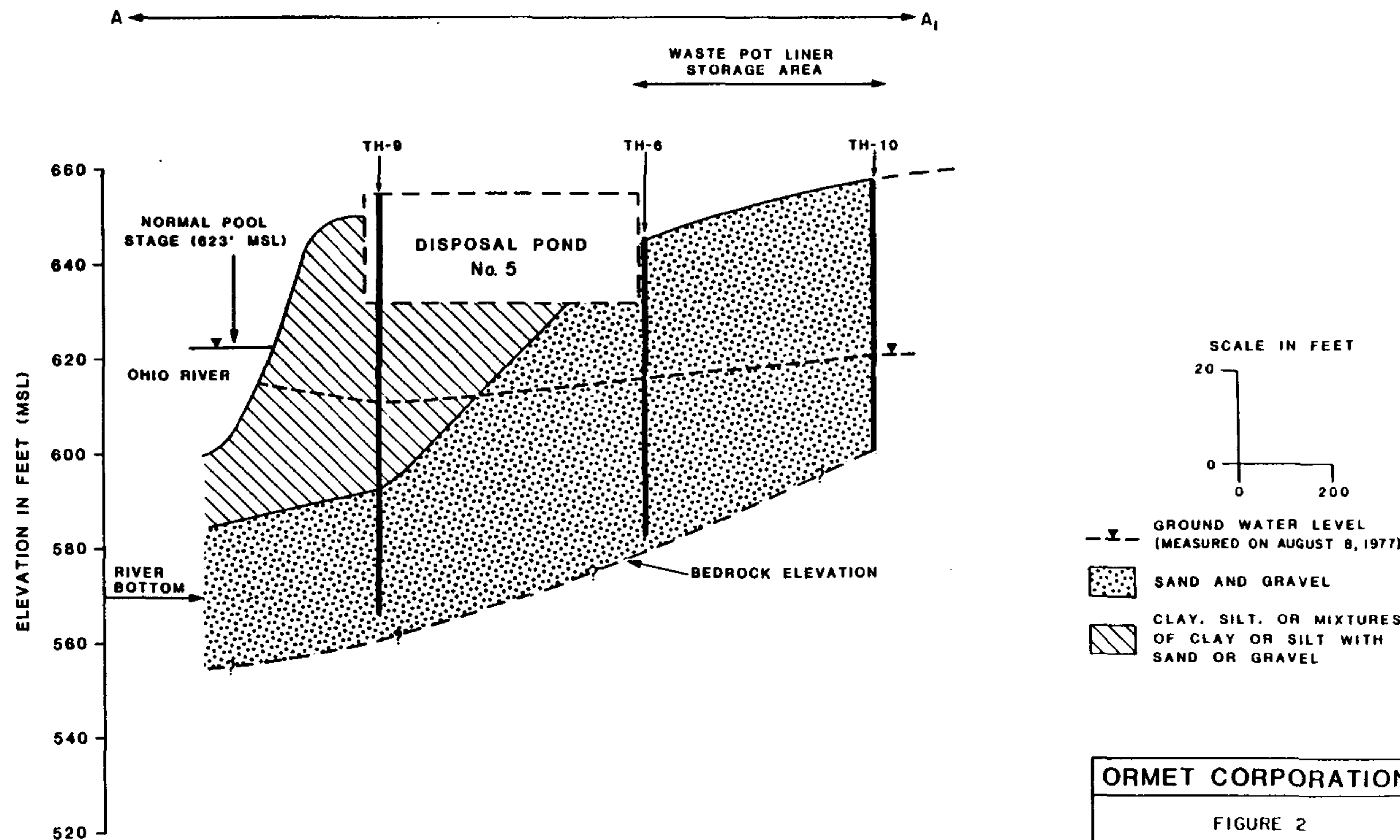
MEAN MONTHLY TEMPERATURE, PRECIPITATION, AND EVAPORATION NEAR HANNIBAL, OHIO

	Precipitation* (inches)	Temperature* (degrees)	Evaporation** (inches)
January	3.73	34.7	-
February	2.92	35.0	-
March	4.05	42.8	-
April	3.60	53.2	-
May	4.21	63.8	5.24
June	4.54	72.9	6.05
July	4.47	76.1	6.05
August	4.57	74.6	5.23
September	3.10	68.0	4.13
October	2.52	56.8	2.79
November	2.91	44.1	-
December	3.40	34.8	-
Annual	44.02	52.9	40-45†

*Measured at New Martinsville, West Virginia (U.S. Department of Commerce, 1974).

**An average of pan evaporation rates measured at Senecaville Lake, Ohio for the period of 1972 through 1976 (NOAA). Measurements were only made from May to October.

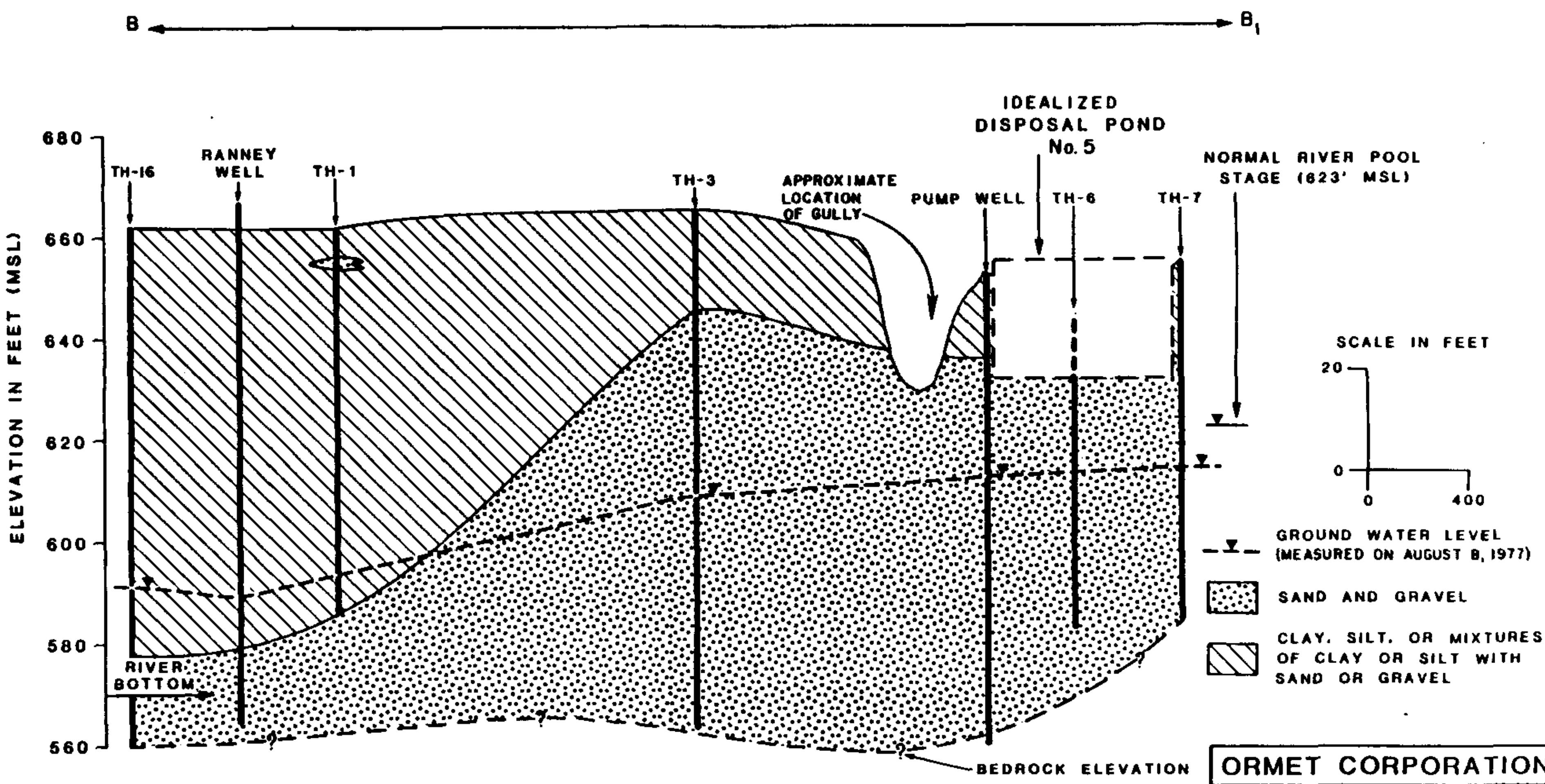
†Mean annual pan evaporation (U.S. Department of Commerce, 1968).



ORMET CORPORATION

FIGURE 2
CROSS SECTION
A – A_1

DAMES & MOORE



NOTE:

ALL LITHOLOGIC AND WATER TABLE DATA ARE PROJECTED TO LINE B-B_1. ALL SURFACE FEATURES ARE IDEALIZED.

ORMET CORPORATION

FIGURE 3

CROSS SECTION

$B-B_1$

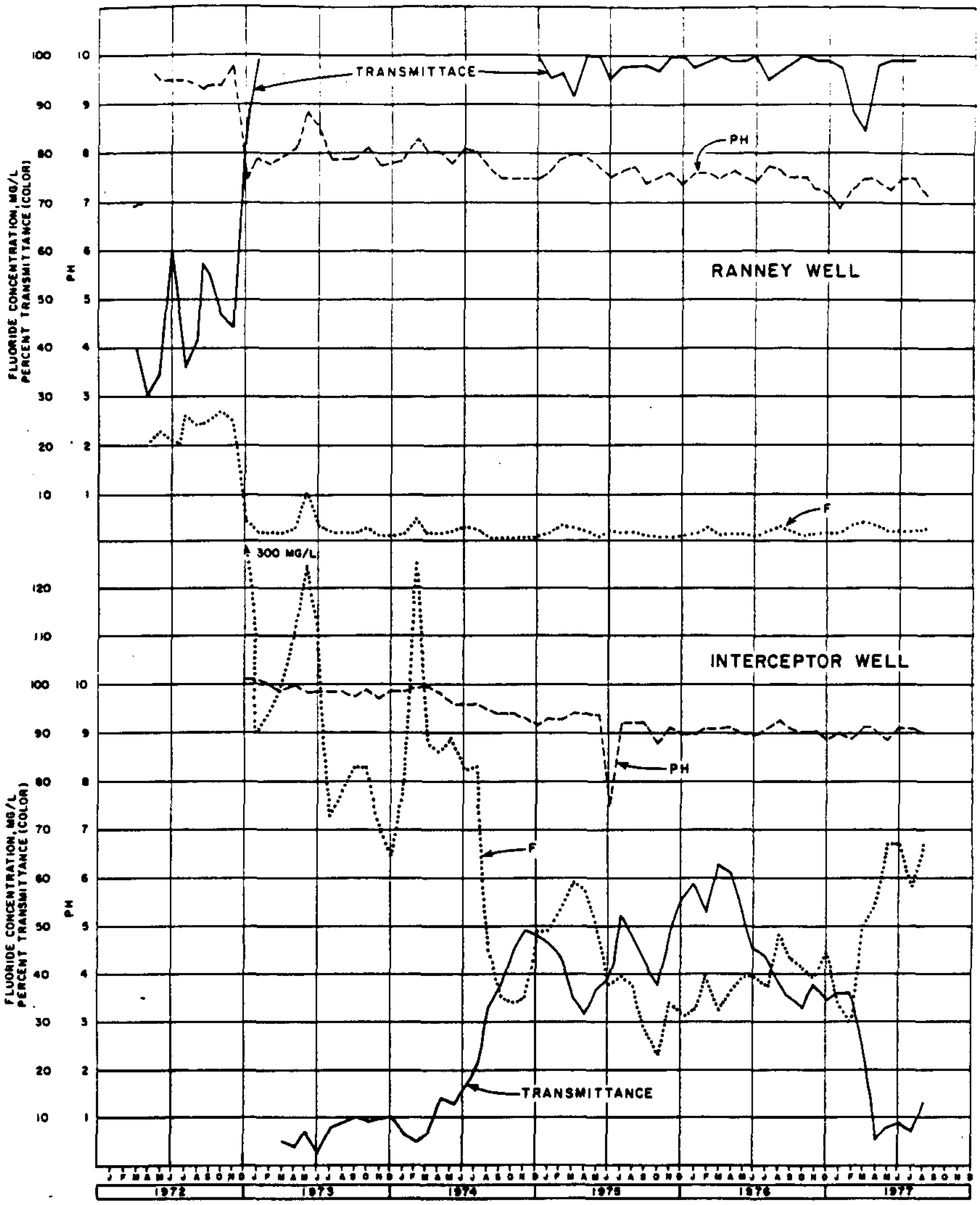


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FIGURE 6
GRAPH SHOWING FLUCTUATIONS
OF FLUORIDE CONCENTRATIONS,
TRANSMITTANCE AND PH
VERSUS TIME

sampler, relatively undisturbed samples were obtained from the borings and test pits for soil testing and leachate extract analysis. Table 1 lists the depths and results of physical testing of sludge and soil samples in the laboratory.

The water levels in seven wells were measured by Ormet personnel, abbreviated water level drawdown and recovery tests were made in response to pumping, and water samples were taken for analysis during the pumping of the wells. The series of drawdown tests were conducted and water samples collected twice, on or about August 25, 1978 and November 9, 1978. The construction features of the wells and water levels are listed in Table 2 and the results of the water analyses are listed in Table 3. Ormet Corporation also made chemical analyses of leachate from sludge samples. The results of which are shown in Table 4.

RESULTS OF INVESTIGATION

WATER QUALITY

Ormet Corporation, at Dames & Moore's direction, collected ground water samples for laboratory analyses from all available wells and from puddled water on the plant site. Well water samples were to have been taken after 2, 4, 6 and 8 casing volumes had been pumped from the well. This was suggested in order to flush the casing, to evaluate any possible layering of contamination in the aquifer near the well, and to assess the integrity of the well. However, in some cases water samples were collected at less than the volumes specified. This was in part due to low specific capacities (productivity) of the individual wells with respect to the pumping equipment used. In those cases, the pumping water level would rapidly decline to the pump intake curtailing further pumping at the normal pumping rate of 10 or 12 gallons per minute (gpm). The discharge line should have a valve at the surface to lower the pumping rate and sustain withdrawal thus preventing overpumping the welll.

Results of the analyses of the ground water samples are shown in Table 3 and the sampling locations are on Figure 1. The analyses showed that water from the wells nearest to the disposal areas, the 8-inch well and wells TH3, TH7, and TH11 contained the highest fluoride (8.6 to 64.8 mg/l) and dissolved solid (500 to 3500 mg/l) concentrations. However, water from well TH15 as sampled in August 1978 also contained high fluoride (47.4 mg/l) and dissolved solids (400 mg/l) concentrations. Subsequent sampling and analyses of water from TH15 showed fluoride concentrations of from 2.4 to 4.6 mg/l. The validity of the water samples collected in August from well TH15 is suspect. Poor quality water should be intercepted by the Ranney and the interceptor wells and should not reach well TH15 unless there is an unknown source of contamination. Transmittance (0 to 24 percent) was very low for water from the above wells, except for well TH3 (79 to 81 percent). Hardness values for the wells were generally high ranging from 30 to 255 mg/l. Chloride concentrations which ranged from 39 to 84 mg/l were below U.S. EPA National Interim Drinking Water Standards. Cyanide was below or near detection limits (<0.01 mg/l), except in the first sample from the 8-inch well where it was 0.02 mg/l. Values of pH ranged from 6.6 to 9.5. Ammonia was detectable only in wells TH4 and TH11, which are near the waste pot lining storage areas and in wells TH12 and TH15.

Table 3 also lists the ranges of fluoride and chloride concentrations and ranges of transmittance and pH levels from chemical analyses performed in 1972. The current levels of those constituents in the ground water indicate an improvement in ground water quality since 1972. Fluoride concentrations have decreased markedly in ground water samples from the 8-inch well and wells TH3, TH7, and TH17. The August 1978 contaminant concentrations in well TH15 is discounted. The degree of light transmittance has not changed significantly in any of the ground water samples. Units of pH have remained constant or decreased 1 to 2 units, except in ground water from well TH12 where it has increased 1 to 2 units. Chloride concentrations are much lower than 1972, except in wells TH12 and TH17, where increases by a factor of about 1.5 to 4 have occurred.

The improvement of ground water quality can probably be attributed to the neutralization treatment of the effluent containing the sludge before it is discharged into the disposal pond, the partial stabilization of abandoned disposal ponds and the continued removal of sources of contaminants such as waste pot linings. Although there has been an increase since 1972 of pH in well TH12 and of chloride in wells TH12 and TH17, only the additional fluoride constitutes a deterioration of the water with respect to the standards listed in Table 3. Chloride concentration and pH levels are still within the standards. Only ground water from wells TH12 and TH17 do not substantially exceed National Interim Drinking Water Standards for fluoride and only ground water from TH12 and TH15 contains less than the standards for dissolved solids. All samples from the wells except wells TH3 and TH15 are within the pH range of 6.0 to 9.0, and all samples contained less than 250 mg/l chloride.

Water samples from puddles were found to be of much worse quality than the ground water samples from the wells. Fluoride concentrations ranged from 314.0 to 3,340.0 mg/l; dissolved solids, 5,800 to 42,000 mg/l; hardness, 0 to 45 mg/l; transmittance, 20 to 95 percent; pH, 9.4 to 10.7; chloride, 43 to 137 mg/l; cyanide, 0.02 to 31.0 mg/l; and ammonia, 0.74 to 12.80 mg/l. These concentrations indicate a badly polluted potential surface source of contamination. Fortunately, the source is of limited extent and also the ground surface and bottom of many of the puddles are compacted by vehicle traffic so that downward percolation is inhibited. However, this potential source of ground water contamination should not be lightly dismissed and efforts to ensure rapid plant drainage to prevent accumulation of contaminated water should be encouraged.

SOURCES OF CONTAMINATION

Waste Disposal Ponds

The shallow subsurface at the five waste disposal ponds, the waste pot lining storage area, and the gully at Outfall No. 4 was investigated by borings and test pits. Field tests of the sludge material in the waste disposal ponds found that the material has a moderately low permeability ranging from 4.0×10^{-4} centimeters per second (cm/sec) to 2.9×10^{-5} cm/sec and averages 1.3×10^{-4} cm/sec. The test results are listed in Table 5. Three laboratory falling head tests of the sludge material (Table 1) resulted in an average permeability of 4.6×10^{-5} cm/sec. This value is about one-half the order of magnitude lower than the average of the field permeability test results. This is probably due to some consolidation and packing during sample collection and transport. Based on these field and laboratory test results, the permeability of the sludge is moderately low but sufficiently high to permit infiltration of water through the sludge.

Typically, the sludge surface is dry to a depth of 8 to 10 inches when not covered by standing water. Below 8 to 10 inches, the sludge is saturated thus indicating the sludge retains moisture and does not drain readily. The result of other laboratory tests, to be discussed more fully later, showed that for a sludge sample from 5.5 to 7.0 feet at SB3 in disposal pond 4 the moisture content was 66.3 percent (Table 4).

Thus, the infiltrating water is inhibited and the physical flushing of the sludge is likely to be very slow.

The average infiltration rate in the abandoned sludge disposal ponds is assumed to be about 15 inches per year. The remaining 29 inches per year average precipitation is dissipated through evaporation and runoff, (Dames & Moore, 1977, Table 4). The permeability is quite sufficient to allow that quantity of water to infiltrate. This would result in the same quantity of water escaping from the pond as seepage, largely to the ground water.

Sludge Leachability

Analyses of leachate from testing the sludge, listed in Table 4, indicated concentrations of constituents similar to those in the ground water samples. Fluoride ranged from 2 to 218 mg/l; dissolved solids, 200 to 2,400 mg/l; cyanide <0.01 to 0.45 mg/l; and ammonia, <0.01 to 1.52 mg/l. For more than half of the samples, the first leach, although not significantly higher. The highest concentration of fluoride in the leachate from all the samples was from a sludge at SB5 at about 5 feet. There is no direct indication that the leachability of the source material increases with depth.

The chemical characteristics of the sludge material is not clearly known. Tests were made to assess the leachability of various constituents of the sludge in order to attempt to quantify the mass of contaminates percolating to the ground water system as a measure of the contamination potential of the waste disposal ponds.

The chemical and physical characteristics of the sludge and the percolating waters and the types and concentrations of the different fluoride compounds control the amount of fluoride ions flushing from the sludges to the ground water. Calcium ions from lime and fluoride ions from the effluent precipitate as calcium fluoride, CaF_2. After equilibrium is established, this reaction provides a chemical mechanism to control the concentration of fluoride ions that can be flushed from the sludge. Aluminum also forms strong complex ions such as AlF^{++} with the fluoride ions. The stability of CaF_2 is highest at a pH of about 7 to 9. If the pH becomes strongly acidic, disassociation may take place and excess fluoride may be released. Of interest is the relative stability of the fluoride ions implied by the results of the leach tests. The amount of water added to the sample during each test was about 50 or 60 pore volumes of the sludge sample and yet the second leach test of the same sample commonly did not result in a substantial decrease in effluent concentrations. There is an implication that there is likely a pH-controlled equilibrium between the effluent water and calcium and fluorides concentrations which limit the concentration of those ions in the effluent. Conversely, if such an equilibrium does not exist, then the second leach test of the same sample would result in a much lower concentration of fluoride. Under that assumption, the amount of fluoride released would be substantially diluted by the excess pore volume of added water. Thus, the test results are not entirely conclusive but can be used as a guide for formulating future testing procedures.

It must be concluded that the sludge ponds are sources of fluoride contamination to the ground water. The present concentration of fluoride in the ground water correspond similarly to concentration of fluorides from the leach test possibly reinforcing the belief that under present ranges of pH that an equilibrium between the fluoride and calcium likely exist. The higher concentration of fluoride in the ground water in 1972, up to 900 mg/l, can not be readily explained unless they were the result of the effluent to the ponds under pre-neutralization plant conditions and from the pot lining storage area.

The highest concentrations of fluoride in the ground water is in the vicinity of the 8-inch well, and wells TH3 and TH7, all of which are within 200 feet of a disposal pond. Thus, it is likely that the disposal ponds are contributing fluoride to the ground water. The higher concentration of fluoride in the 8-inch well suggests that waste disposal pond no. 5 is responsible for much of the current contamination.

Ground water samples from well TH11, which probably represent the effluent from the waste pot storage areas, contain lower concentrations of fluoride than ground water from the 8-inch well and wells TH3 and TH7. This suggests that the waste pot storage areas are not now the major source of fluoride.

However, the original pot lining material rapidly leached fluorides which exposed to precipitation. This could have contributed substantial amounts of fluoride to the system earlyon.

Pits SB8 and SB9 within the gully near Outfall No. 4, found clay within 3 feet of the surface. This clay should effectively retard infiltration of contaminants from Outfall No. 4 to the ground water in the aquifer in this area.

An estimated fluoride mass balance shows that the amount of fluoride being removed from the ground water by the interceptor and Ranney wells is much greater than the amount that appears to be entering it through the sludge disposal ponds. The interceptor wells, pumping a high average of 500 gpm of water that contain about 80 mg/l of fluoride, removes about 1.8×10^5 pounds of fluoride per year. The Ranney well, pumping 1350 gpm of water that contains 2.8 mg/l of fluoride, removes about 1.6×10^4 pounds of fluoride annually. Thus, there is a total of 1.9×10^5 pounds of fluoride being removed by the wells annually. The combined area of ponds 1-4 is 232,000 ft^2 (Dames & Moore, 1977, p. 6), and, if an estimated 15 inches of precipitation flush water containing an average of 40 mg/l of fluoride (estimate from Table 4) then about 7.3×10^2 pounds of fluoride enters the ground water from pond 1-4 annually.

The amount of fluorides being contributed by Pond No. 5 is unknown. Pond No. 5 has a surface area of 470,000

ft^2 and is currently covered with treated effluent from the neutralization plant. If it is assumed that the average permeability of the sludge is 9.4×10^{-5} cm/sec and if there is an average of 2 feet of water standing over an average of 20 feet of sludge, then leakage through the sludge is about 1,000,000 gal/day. This figure seems much to high. Previous inflow-outflow studies show very little loss in the pond. If it is assumed that the effective permeability is only 1×10^{-5} then about 100,000 gallons per day could be leaking to the ground water system. If it is further assumed that the seepage water contains 100 mg/l fluoride then the total fluoride contribution from Pond No. 5 is 3×10^{4} lb/yr. Obviously, the leakage from Pond No. 5 is a key factor in determining the fluoride balance. It is hard to imagine that losses greater than 100,000 gallons per day would escape detection and that substantially greater concentration of fluoride would be generated. At present, Outfall No. 4 carries about 1 mgd of effluent containing about 35 mg/l fluoride from Pond No. 5. Thus, there is a discrepancy of fluoride being contributed. The contribution of fluoride from the waste pot storage areas is not large enough to make up the deficit. Some of the fluoride presently being pumped out could be from fluoride in temporary storage in the ground water which is being flushed from the system. Unfortunately, there has been no continuous monitoring of ground water quality to be able to address the possibility. It is concluced that additional information is needed to refine the fluoride mass balance.

Test Well Drawdown and Recovery Tests

Prior to and during the pumping of available test wells for water samples the ground water levels were measured. The specific capacity of the wells was calculated from the data and is expressed as the pumpage rate from the wells (gpm) divided by the drawdown (feet) and is a measure of the wells productivity. This was done to evaluate the suitability of test wells for use as interceptor wells. Based on location, only the 8-inch test well and well TH3 are positioned to capture contaminated ground water prior to its migration to the Ranney well and the two existing interceptor wells. Both of these wells have reasonable specific capacities also. The 8-inch test well is constructed with 8-inch ID casing to a reported 92 feet and TH3 is constructed with 6-inch ID casing to a reported 104.5 feet. Both wells appear to have sand and gravel material heaved into their casings at a depth of 87 and 91 feet, respectively. These wells could possibly be pumped at about 100 gpm as is, however to pump at 200 to 250 gpm and to preclude the possibility of excessive sand wear on the pumps, the wells should be cleaned out and 5 to 10 feet of screens installed.

Reclamation of Waste Disposal Ponds

Selected sludge samples from the waste disposal ponds were subjected to various physical laboratory tests. The soil

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

BORING[a]	LOCATION[d]	DEPTH (FEET)	SOIL TYPE	GRAIN SIZE	FIELD MOISTURE	DRY DENSITY (lb/cu.ft.)	PERMEABILITY[b] (cm/sec)	LIQUID LIMIT	PLASTIC LIMIT
SB-1	DP#1	0.0- 1.5	sludge	7.1% < #200	127.2	37.9	1.2×10^{-5} FH	—	—
SB-1	DP#1	3.0- 4.5	sludge	—	114.2	41.9	—	—	—
SB-1	DP#1	8.5-10.0	sludge	—	127.3	38.9	—	—	—
SB-2	DP#5	0.0- 1.5	sludge	33.8% < #200	33.0	69.4	—	—	—
SB-2	DP#5	1.5- 3.0	sludge	—	33.5	75.0	—	—	—
SB-2	DP#5	4.5- 6.0	sludge	53.7% < #200	54.9	70.1	—	—	—
SB-3	DP#4	0.0- 1.5	sludge	—	54.9	70.1	5.7×10^{-5} FH	—	—
SB-3	DP#4	5.5- 7.0	sludge	—	108.0[c]	43.5	—	55	53
SB-3	DP#4	7.0- 8.0	sludge	28.8% < #200	95.2	46.9	—	—	—
SB-4	DP#2	0.0- 1.5	sludge	—	48.7	—	—	—	—
SB-5	DP#1	0.0- 1.5	sludge	—	—	—	6.9×10^{-5} FH	—	—
SB-8	G	8.3- 9.0	clay	96.8% < #200	33.1	—	—	—	—
SB-9	G	9.8-11.4	silty clay	51.4% < #200	17.9	—	—	—	—
SB-10	WP	7.0- 8.0	sand & gravel	2.0% < #200	5.9	—	7.3×10^{-2} HZ	—	—
SB-11	WP	11.0-12.6	sand & gravel	3.6% < #200	7.7	—	4.0×10^{-2} HZ	—	—
SB-12	G	11.5-12.5	clay	—	—	—	—	—	—

[a] See Figure 1 for location of borings.

[b] FH = Laboratory falling head test.
HZ = Hazen's approximation, $K = 100(D_{10})^2$.

[c] Hygroscopic water content = 66.3%.

[d] DP = Disposal pond.
WP = Waste pot lining storage area.
G = Gully near outfall 4.

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TABLE 2

SUMMARY OF WELL CONSTRUCTION

WELL NO.	SOUNDED DEPTH (FEET) 2/72	DEPTH OF CASING (FEET)	CASING DIAMETER (INCHES)	FINISH	ELEVATION OF TOP OF CASING (MSL)	ELEVATION OF GROUND SURFACE (MSL)	SPECIFIC CAPACITY (GAL/MIN/FT)	WATER LEVEL BELOW GROUND (FEET) 2/72	8/78	11/78	REMARKS
8" test well	87.0	92.0	8	open hole	654.2	652.2	8.3	50.7	39.0	39.1	
TH 0	99.0	—	6	open hole	666.0	665.5	—	92.9	—	—	
TH 1	96.1	101.0	6	open hole	664.0	662.2	—	86.8	—	—	
TH 2	—	—	—	—	—	—	—	—	—	—	
TH 3	91.1	104.5	6	open hole	667.5	665.0	15.2	70.6	55.9	55.8	
TH 4	84.6	89.5	6	open hole	651.8	649.3	—	27.9	—	—	
TH 5	67.9	86.0	6	open hole	653.7	651.2	—	49.0	—	—	
TH 6	57.2	63.0	6	open hole	646.4	644.9	—	41.9	—	—	
TH 7	59.3	73.8	6	open hole	658.2	656.4	3.5	51.0	35.2	—	
TH 8	73.7	73.8	6	open hole	649.6	647.7	—	44.7	—	—	
TH 9	73.5	82.0	6	open hole	648.4	646.2	—	43.5	—	—	
TH 10	50.9	56.7	6	open hole	658.2	656.5	—	41.5	—	35.4	
TH 11	50.1	57.2	6	open hole	658.8	657.1	1.4	35.4	35.3	—	
TH 12	68.1	74.0	6	open hole	638.6	635.6	0.5	32.8	6.1	—	
TH 13	60.4	67.0	6	open hole	631.3	630.3	—	27.4	—	—	
TH 14-A	55.5	—	6	5' screen	653.4	651.6	—	48.3	—	—	
TH 15	98.6	102.0	6	5' screen	663.6	—	1.1	75.5[a]	72.6 BTOC[b]	—	
TH 16	97.0	102.0	6	5' screen	664.3	662.9	—	80.0	—	70.2	
TH 17	—	—	6	5' screen	663.6	661.5	9.7	73.8[a]	71.2	68.6	
TH 18	—	—	—	—	—	660.8	—	—	—	—	
TH 19	98.2	—	—	—	662.6	660.8	—	79.2	—	—	

[a]Water level from 7-18-72.

[b]BTOC = below top of casing.

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TABLE 3

SUMMARY OF WATER ANALYSES

SAMPLE NO.[a]		DATE	GALLONS PUMPED	CASING VOLUME	FLUORIDE (mg/l)	DISSOLVED SOLIDS (mg/l)	HARDNESS (mg/l)	TRANSMITTANCE (%)	pH	CHLORIDE (mg/l)	CYANIDE (mg/l)	AMMONIA (mg/l)
Drinking Water Standards			—	—	1.2–2.4[g]	500[e]	—	—	—	250[e]	0.01[e]	—
Ohio River Standards			—	—	1.0	500	—	—	6.0–9.0	250	0.025	0.05
8" well,	#1	08-25-78	0	0	60.4	2,800	60	15	8.8	84	0.02	0.00
	#2	08-25-78	13.9	1.4	60.4	2,700	60	13	8.7	82	0.01	0.00
	#3	08-25-78	41.7	4.2	58.4	2,400	60	13	8.6	71	<0.01	0.00
	#4	08-25-78	83.4	8.4	58.4	2,000	80	12	8.5	84	<0.01	0.00
	#5	08-25-78	166.8	16.8	64.8	3,500	65	24	8.8	80	<0.01	0.00
	#6	11-09-78	—	3	69.5	2,600	—	12	8.0	—	0.09	0.00
	#7	11-09-78	—	6	64.0	2,400	—	12	8.9	—	0.03	0.00
	#8	11-09-78	—	12	62.3	2,200	—	11	8.7	—	0.02	0.06
		1972 Range	—	—	260–1100	—	—	0–96	10.1–10.9	2766–4100	—	—
Well #3,	#1	08-25-78	6.3	0.1	14.0	600	40	79	9.5	46	<0.01	0.00
	#2	08-25-78	176.4	4.1	10.3	600	75	87	9.2	43	<0.01	0.00
	#3	08-25-78	264.6	6.2	9.9	500	85	90	9.1	44	<0.01	0.00
	#4	08-25-78	378.0	8.8	9.9	500	100	91	9.1	39	0.01	0.00
	#5	08-26-78	1440[d]	34[d]	9.2	—	—	—	—	—	—	—
	#6	08-31-78	2520[d]	59[d]	9.9	—	—	—	—	—	—	—
	#7	11-09-78	—	3	15.1	700	100	74	9.1	48	0.00	0.17
	#8	11-09-78	—	6	12.3	600	115	82	8.9	45	0.01	0.03
	#9	11-09-78	—	12	11.5	600	125	83	8.9	59	0.01	0.17

[a] See Figure 1 for location of wells and puddles.

[b] Insufficient sample.

[c] Sample contains metal particles.

[d] Pumping rate assumed to be 12 gpm.

[e] U.S. Public Health Service, 42 CFR, § 72.205, 1971.

[f] Ohio River Standards, Ohio EPA, Chapter 3745-1-12, Ohio Administrative Code, effective February 1978.

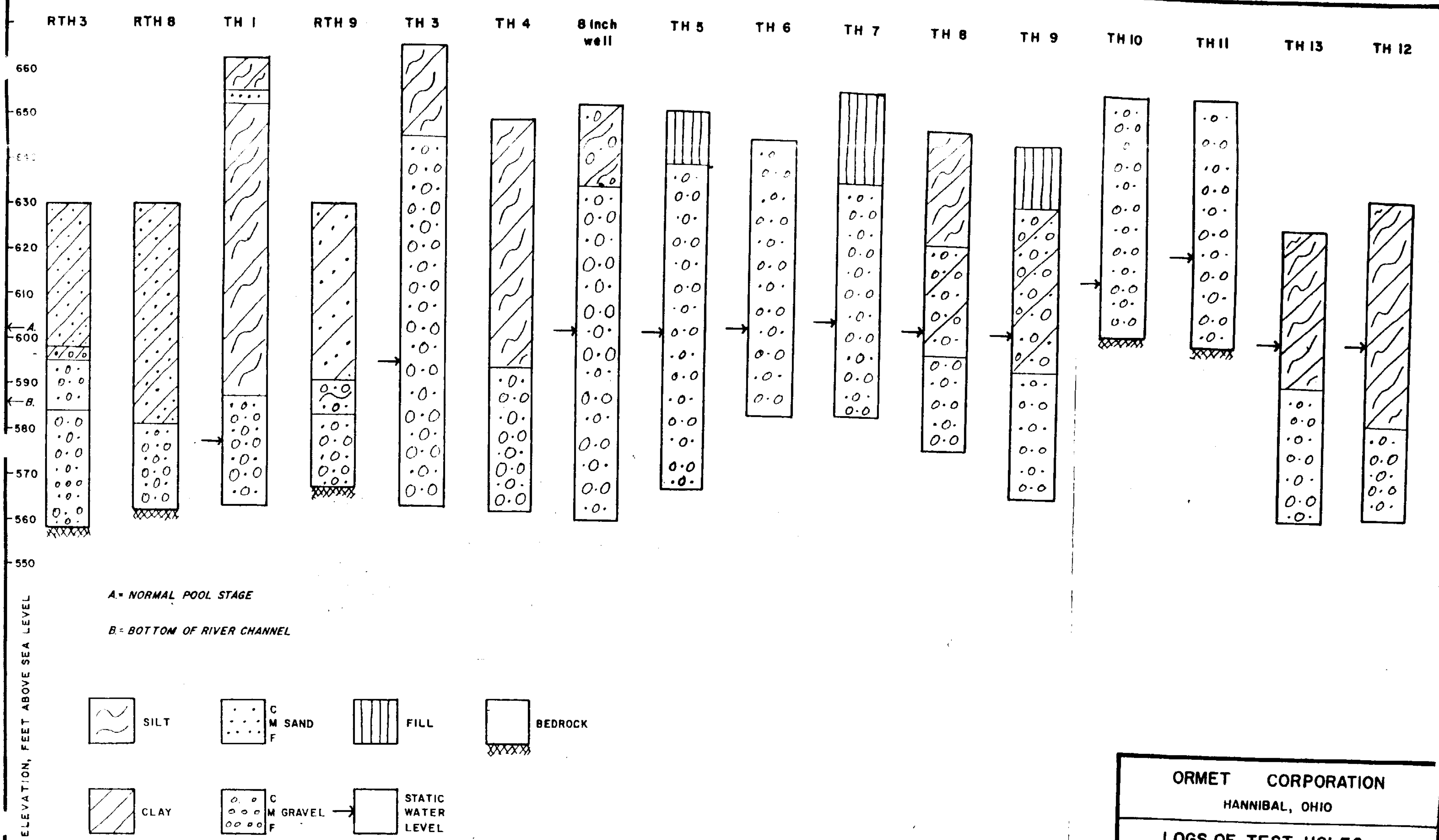
[g] U.S. EPA National Interim Primary Drinking Water Regulations, effective June 1977.

TABLE 3 (continued)

SAMPLE NO.[a]	DATE	GALLONS PUMPED	CASING VOLUME	FLUORIDE (mg/l)	DISSOLVED SOLIDS (mg/l)	HARDNESS (mg/l)	TRANSMITTANCE (%)	pH	CHLORIDE (mg/l)	CYANIDE (mg/l)	AMMONIA (mg/l)
1972 Range	—	—	—	150-468	—	—	0-89	9.2-10.1	390-443	—	—
Well #7, #1	08-29-78	19.8	1.3	27.2	700	—	0	7.2	35	<0.01	0.34
#2	08-29-78	66.0	4.2	34.4	700	40	9	7.9	43	<0.01	2.10
	1972 Range	—	—	250-364	—	—	0	9.8-10.0	—	—	—
Well #10, #1	11-09-78	—	1.8	47.4	1,500	—	1	8.0	—	0.00	0.00
#2	11-09-78	—	2.1	48.3	1,500	—	0	7.9	—	0.00	0.00
#3	11-09-78	—	2.4	43.4	1,500	—	0	7.9	—	0.00	0.00
	1972 Range	—	—	0.9-10.0	—	—	2-98	7.2-8.1	128	—	—
Well #11, #1	08-28-78	18[d]	1[d]	8.6	500	120	15	6.6	51	—[b]	0.49
	1972 Range	—	—	1.4-10.1	—	—	0-95	6.9-7.9	117-142	—	—
Well #12, #1[c]	08-29-78	12[d]	1[d]	0.3	200	40	98	8.2	69	<0.01	0.06
#2[c]	08-29-78	—	—	0.4	200	50	97	9.0	74	<0.01	0.00
	1972 Range	—	—	0.2-0.9	—	—	21-98	6.8-7.2	19	—	—
Well #15, #1[c]	08-29-78	18[d]	1[d]	47.4	400	30	81	9.4	36	—[b]	3.50
#1	12-01-78	104.0	4.4	4.8	—	—	—	7.3	—	—	—
#2	12-01-78	104.0	5.9	4.7	—	—	—	7.3	—	—	—
#3	12-01-78	198.5	8.3	2.7	—	—	—	7.3	—	—	—
	1972 Range	—	—	1.0-2.7	—	—	87-99	7.2-8.2	21-32	—	—
Well #16, #1	11-09-78	—	2.1	0.9	300	150	100	7.4	30	0.04	0.00
#2	11-09-78	—	4.6	0.7	300	165	100	7.7	30	0.00	1.02
	1972 Range	—	—	1.0-1.8	—	—	90-99	7.9-8.6	27	—	—
Well #17, #1	08-28-78	5.3	0.2	0.3	300	95	80	8.3	51	<0.01	0.00
#2	08-28-78	74.2	2.5	<0.2	500	255	94	7.3	48	0.01	0.00
#3	08-28-78	159.0	5.3	<0.2	500	255	100	7.3	43	0.01	0.00
#4	11-09-78	—	0.7	<0.2	300	245	100	7.6	43	0.00	0.00
#5	11-09-78	—	2.05	<0.2	400	260	100	7.3	42	0.00	0.00

TABLE 3 (continued)

SAMPLE NO.[a]		DATE	GALLONS PUMPED	CASING VOLUME	FLUORIDE (mg/l)	DISSOLVED SOLIDS (mg/l)	HARDNESS (mg/l)	TRANSMITTANCE (%)	pH	CHLORIDE (mg/l)	CYANIDE (mg/l)	AMMONIA (mg/l)
		1972 Range	—	—	0-2.4	—	—	30-99	7.3-7.9	34-39	—	—
Puddle	A	08-31-78	—	—	640.0	9,200	30	88	10.1	49	3.30	6.20
	B	08-31-78	—	—	490.0	6,700	0	90	9.8	137	0.02	0.74
	C	08-31-78	—	—	430.0	5,800	35	20	10.0	53	0.50	0.75
	D	09-07-78	—	—	920.0	42,000	15	91	10.2	52	2.4	12.8
	E	09-07-78	—	—	314.0	8,600	45	95	9.4	59	0.07	1.8
	F	09-07-78	—	—	3340.0	36,000	0	87	10.7	43	31.0	8.6
	G	11-10-78	—	—	207.0	2,600	10	100	8.5	—	0.02	0.09
	H	11-10-78	—	—	122.5	4,400	40	100	8.3	—	0.02	0.00



ORMET CORPORATION
HANNIBAL, OHIO

LOGS OF TEST HOLES

FRED H. KLAER JR. & ASSOCIATES

HYDROGEOLOGIC CONDITIONS AT THE ORMET CORPORATION PLANT SITE HANNIBAL, OHIO

PREPARED FOR

ORMET CORPORATION
HANNIBAL, OHIO

MAY 1984

Geraghty & Miller, Inc.
GROUNDWATER CONSULTANTS
ANNAPOLIS, MARYLAND

Geraghty & Miller, Inc.

exhibit B

HYDROGEOLOGIC CONDITIONS
AT THE
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GERAGHTY & MILLER, INC.
GROUNDWATER CONSULTANTS
ANNAPOLIS, MARYLAND

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INTRODUCTION

Plant Setting and Operational History

The Ormet Corporation (Ormet) plant site in Monroe County, Ohio, is situated along the west bank of the Ohio River, approximately 35 miles south of Wheeling, West Virginia. The plant occupies the northeastern half of an area known as Buck Hill Bottom, a lens-shaped stretch of land approximately 2.5 miles long and about 0.5 miles wide, at its widest point (see Figure 1). The southwestern half of Buck Hill Bottom is occupied by another industrial facility.

Ormet has used this plant site for more than 25 years, over which time, their main process has been the reduction of alumina to produce aluminum metal. Throughout the life of the plant, groundwater has constituted an important source for processing- and sanitary water supplies, and is produced via two Ranney collector wells located to the south of the Ormet plant and the neighboring facility. At the present time, these wells are producing a total of about six million gallons of water per day (gpd).

As a result of past storage and disposal practices, inorganic constituents have seeped into Ormet's groundwater,

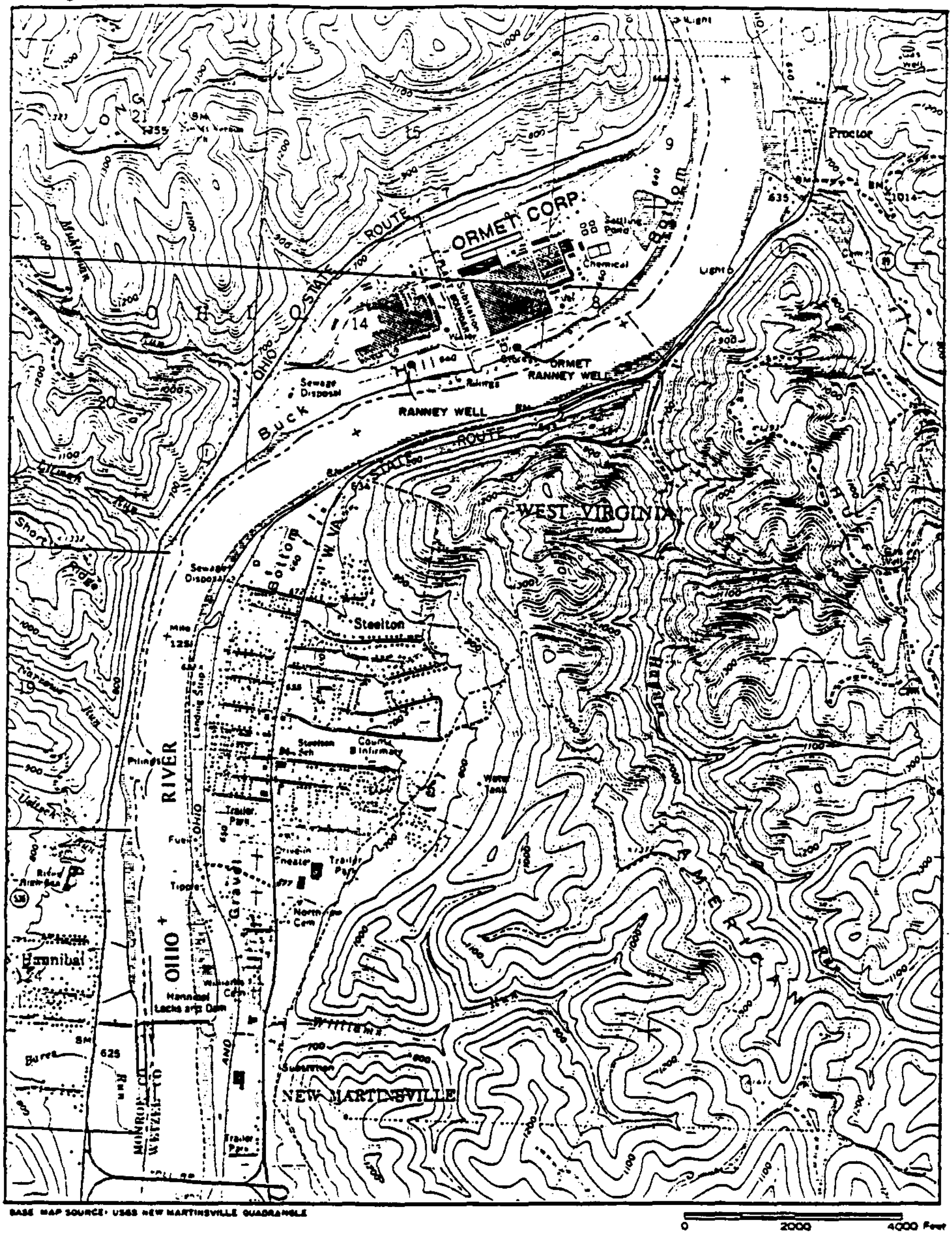


Figure 1. Location of the Ormet Corporation Plant Site, Hannibal, Ohio.

supplies; and, in some areas, concentrations of extraneous substances have reached levels that are undesirable for process-water uses. As a result, several interceptor wells have been installed to recover degraded groundwater before it reaches the Ormet Ranney well.

As a preliminary effort to identify and define the nature and extent of impacts to groundwater supplies, Ormet has sponsored several site hydrogeologic investigations, including studies by Fred Klaer and Associates (1972) and Dames & Moore (1977 and 1978). Results from these studies indicated that water quality problems were probably mainly related to sludge disposal and potliner storage practices that were conducted in the northeastern portion of the Ormet plant site (see Figure 1).

Study Objectives and Approach

In October 1983, Geraghty & Miller, Inc., was retained by Ormet to conduct an additional hydrogeologic site investigation to better define the source(s), nature, and extent of groundwater effects, as well as possible remedial alternatives for abating existing and potential conditions. The specific objectives of this study were to:

- Assess (and contour) groundwater flow patterns beneath the site, and identify main factors which control groundwater flow.

- Document the chemical makeup of leachate plumes and (to the limits of available data) identify specific parameters and/or parameter relationships that may account for the appearance and chemical behavior of these fluids.

- Evaluate the extent to which leachate plumes have spread beneath the site and identify main factors controlling plume migration; and estimate future plume movement under present pumping conditions.

- Assess and qualitatively define contaminant/source area relationships, particularly with regard to the potential for further seepage of effluents into the groundwater system.

- Discuss long and short range groundwater quality trends and evaluate possible remedial measures (conceptual) that could be implemented to abate existing and potential impacts to groundwater resources.

In addressing the above objectives, Geraghty & Miller, Inc., first conducted a review of existing data (Phase I). In this review, previous groundwater flow patterns and water-quality trends were inspected, and significant data gaps were identified. A groundwater monitoring program was then designed and implemented to fill data gaps and provide the information needed to fulfill the established study objectives.

PRINCIPAL FINDINGS

The principal findings of the recent investigation conducted at the Ormet site are as follows:

1. Groundwater flow beneath the northeastern portion of Buck Hill Bottom is primarily in the direction of the Ormet Ranney, and old interceptor wells.

2. Under present pumping conditions, it is estimated that a unit volume of groundwater moving beneath potliner storage and sludge disposal areas should reach the Ranney and old interceptor wells within about a year's time (based on calculated flow velocities of 3,300 to 3,700 feet per year); travel times for dissolved groundwater constituents are probably longer, depending on the net retardation factor for a particular constituent.

3. Groundwater effected by storage and/or disposal practices is characterized primarily by elevated pH and above background concentrations of fluoride, cyanide, and sodium; and to a lesser extent (i.e., with lesser consistency), reduced light transmittance and elevated levels of chloride, bicarbonate, carbonate, sulfate, iron, aluminum, silica, total organic carbon (TOC), and probably ammonia.

4. Pumping (and resultant drawdowns) within the water table aquifer have lowered groundwater heads below the water level in the Ohio River and water is moving from the river into the aquifer (i.e., induced recharge); there is no apparent natural discharge of groundwater to the surface water body along most of Ormet's river/plant boundary.

5. Under present conditions, leachate plumes within the groundwater system are being largely contained within Ormet's site boundaries as a result of pumpage from Ranney and interceptor wells. These withdrawals (at or near current rates) must continue in order to prevent offsite migration of leachate plumes.

6. It is believed that well screen incrustation problems (as well as scaling on heat exchange equipment) are related to elevated concentrations of silica and TOC (and possibly other parameters such as aluminum) within high-pH plume fluids; i.e., the solubility of these parameters increases under high-pH conditions. Upon reaching pumping centers, it is believed that plume fluids undergo a net reduction in pH as a result of mixing with unaffected groundwater; and the corresponding decrease in silica and TOC solubilities causes supersaturation of these parameters, which, in turn, results in precipitation (incrustation).

How do you know this?

7. During the time of the Fred Klaer study (1972), it appeared that seepage from sludge disposal facilities (particularly pond No. 5) was a main contributor to observed groundwater impacts; however, under present (1983-1984) conditions, **it appears that water-quality alterations by sludge disposal ponds have become significantly reduced, and current groundwater impacts may be largely related to leachate generation from former potliner storage areas.**

8. It is difficult to definitively ascribe groundwater degradation to either sludge disposal or potliner storage practices, based solely on the chemical makeup of effluents; however, groundwater flow patterns (and, possibly, water temperature trends) do serve as fairly reliable estimators of potliner-related and sludge-related inputs to the groundwater.

9. **As a means of reducing the potential for migration of leachate plumes beyond Ormet's western plant boundary, it is technically feasible to maintain a hydraulic barrier using pumping and/or injection wells. In addition, it may be feasible to accelerate improvement of Ormet's groundwater conditions through implementation of source-area management alternatives and/or plume management practices.**

REGIONAL SETTING

Topography

The Ormet plant site is situated within the Ohio River Valley near the base of the West Virginia Northern Panhandle. This area is part of the Appalachian Plateau physiographic province and, in general, can be described as a highly dissected plateau or plain characterized by rugged topography, steep slopes, and strong relief, with elevations ranging from about 600 feet to more than 1400 feet above sea level. Stream erosion and transport, in conjunction with weathering and mass-wasting of slope materials, is largely responsible for the existing topographic expression of this region.

The Ohio River generally constitutes the feature of lowest elevation throughout the area and, thus, receives virtually all of the natural drainage via tributaries, surface runoff, overland flow, and groundwater discharge. Surface drainage patterns in the region can best be described as dendritic, where larger tributaries branch irregularly and angularly into smaller tributaries, resembling, in plan, the profile of a branching tree.

A notable exception to the rugged topography described above occurs in areas adjacent to the Ohio River and some of its major tributaries where the deposition of flood plains and the carving of terraces into older and higher glaciofluvial outwash has created relatively level or gently inclined strips of land that tend to parallel the course of the river. These land features, which are commonly referred to as bottoms' or bottomlands, are usually best developed on the inside of meanders (bends in a river) and fringe the Ohio River on alternate sides throughout its length. Owing to the relatively flat-laying topography, the availability of water, and the close proximity to a major waterway, bottomlands along the Ohio River have long been major centers of population and industry.

Climate

Climate of the area is typical of temperate continental zones with warm summers and cold winters averaging 73°F (23°C) and 34°F (1°C), respectively. The mean annual temperature for this area is about 53°F (12°C)(Price, and others, 1956).

Precipitation is ample and fairly well distributed throughout the year with maximum and minimum rainfall occurring in summer and fall, respectively. Total annual precipitation in the Ohio Valley increases from north to south. Normal precipitation for Wheeling is approximately 38 inches and for New Martinsville is about 44 inches; it is assumed that average precipitation at the Ormet plant site is similar to that occurring at New Martinsville.

Geology

The region of interest is underlain by Paleozoic-age sedimentary rocks consisting mainly of conglomerates, sandstones, siltstones, shales, fresh-water and marine limestones, and coals, and lesser amounts of chert, iron ore, and rock salt or other evaporites. Coal deposits, which mainly occur in Pennsylvanian-age and, to a lesser extent, Permian-age rocks, have long been recognized as the greatest mineral resource of the Ohio River Valley area. Rock salt and natural brines of Silurian-age are of local importance to chemical industries for the manufacture of chlorine, bleaches, soda ash, and caustic soda.

In hilly, more elevated parts of the region, rock units are generally overlain by a thin to moderately thick layer of sedentary or residual soil that has been formed in place by the disintegration of underlying rocks, and by the accumulation of organic material. These soils are usually relatively fertile and well drained and are capable of supporting woodland, cropland, and pasture. Owing to the hilly topography characterizing these areas, soils tend to be fairly susceptible to erosion.

In areas adjacent to the Ohio River, steep valley walls with outcropping rocks of Pennsylvanian- and Permian-age give way rather abruptly to bottomland alluvial deposits comprising flood-plain and river-terrace features. Upper river terraces generally represent Pleistocene-age glacial outwash plains that have been carved into a stepped profile by the downcutting Ohio River. These features are mainly composed of sand and gravel and, in areas along the edges of the valley, may be capped by colluvium (clay and rock fragments) derived from highlands and the valley wall. Lower river terraces can also represent abandoned flood plains deposited by the river during past, more elevated regimens. Such deposits tend to contain appreciably greater quantities of silt and clay than are found in terraces formed primarily from glacial outwash.

In the Buck Hill Bottom area, two main terrace levels are present with lower and upper terrace elevations averaging about 630, and 665 feet above mean sea level, respectively. The upper terrace, which is occupied by the main plant facilities, is bounded on the northwest by a steep valley wall that rises to an elevation of 1300 feet within less than a mile. The lower terrace comprises a relatively narrow strip of land that is bounded by the Ohio River; the Ohio River pool elevation in this area ranges from 620 to 624 feet above mean sea level and, as a result of the Hannibal lock and dam, tends to remain fairly constant throughout high- and low-flow periods.

Water Resources

The Ohio River represents the main body of surface water in the area and, with respect to volume, constitutes an almost unlimited supply. The quality of water from the Ohio River is suitable for many industrial uses; however, owing to suspended sediments and the possible presence of undesirable chemical constituents resulting from upstream operations, some treatment is usually required prior to use.

In the Buck Hill Bottom area, groundwater constitutes a main source for process- and drinking-water supplies. The most important water-bearing unit is the water-table aquifer, which is comprised of the sand and gravel alluvial materials of the Ohio River Valley. Relatively high yields can be obtained from wells penetrating these sediments, and natural groundwater quality is generally good with total dissolved solids concentrations of 500 mg/l or less; locally, water may be hard and sulfurous (Price, and others, 1956).

At the present time, a total of about 6 million gallons of water is pumped daily (Dames & Moore, 1977) from the alluvial aquifer via the two Ranney wells. Because these withdrawals greatly exceed precipitation recharge, pumping has induced river recharge of the aquifer. Consequently, the quality of water derived from pumping wells is closely related to river water quality, and is thus susceptible to numerous upstream sources of contamination. Owing to this condition, treatment of groundwater used for sanitary water supplies may be necessary.

The Paleozoic bedrock units, which underlie the sand and gravel aquifer, are also capable of producing groundwater. However, because well yields are generally low and water quality is often poor (i.e., mineralized), these units have not been extensively developed as a groundwater supply in the immediate study area.

SITE INVESTIGATION

Drilling and Soil-Sampling Program

During December, 1983, Geraghty & Miller, Inc., conducted a drilling program at the Ormet Corporation plant site. The main objectives of the program were to collect geologic data and establish a system of monitor wells to facilitate the collection of water-level and water-quality data. A total of 20 boreholes were drilled, 19 of which were equipped with 2-inch-diameter monitor well assemblies. Efforts were made to locate most of these wells in areas suspected to be hydraulically downgradient from possible sources of contamination, i.e., sludge disposal ponds and potliner storage areas. Several wells (MW-19 and MW-20) were also installed at locations hydraulically upgradient from the potential source areas, in order to define background water-quality conditions. New monitor-well locations (MW-1 through MW-20), old monitor-well locations (TH-0 through TH-19), and other important site features are shown on Figure 2. Drilling, soil sampling, and monitor-well installation and development was done by Hardin-Huber, Inc., of Pasadena, Maryland, under the supervision of a Geraghty & Miller, Inc., representative.

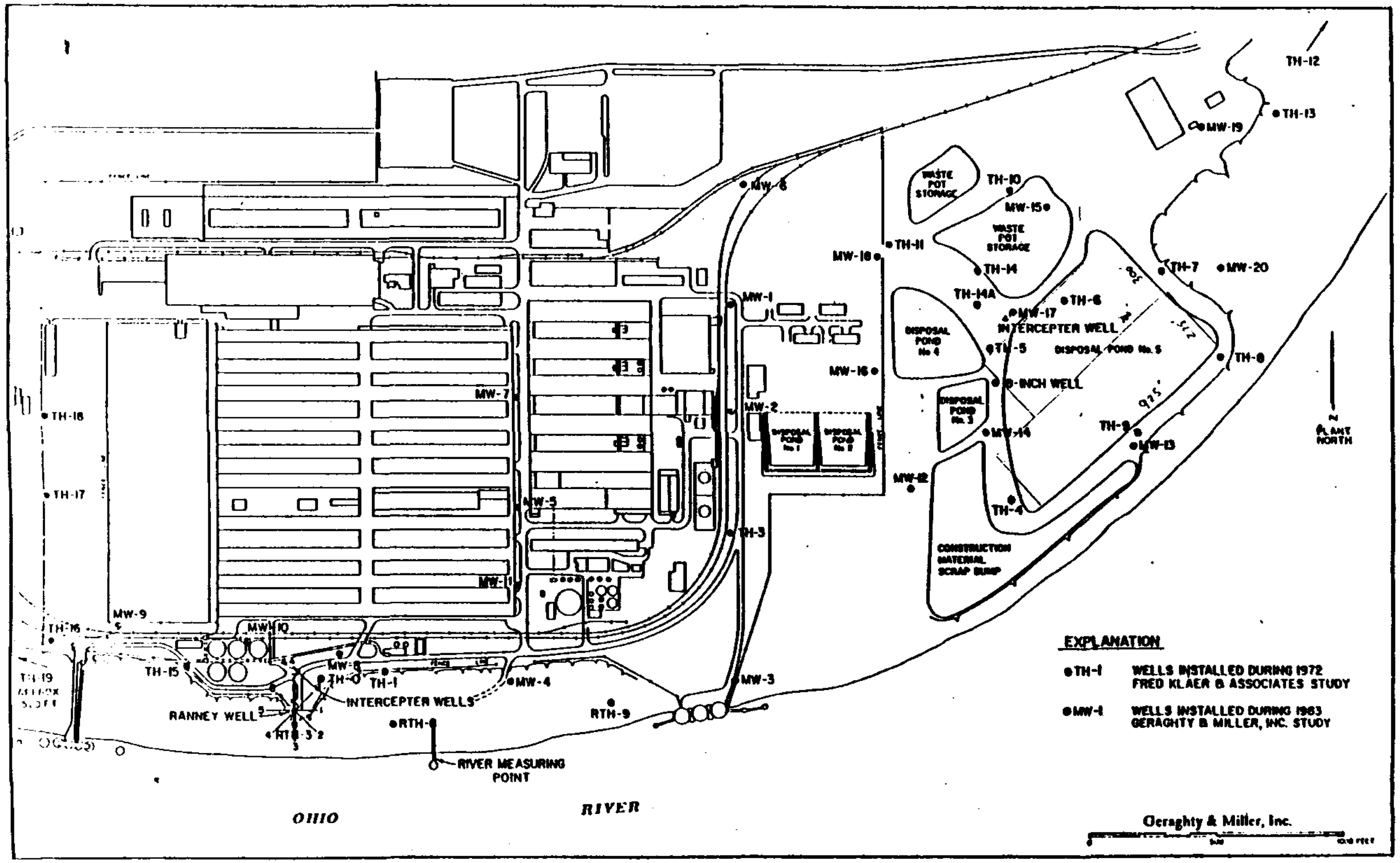


Figure 2. Location of MW-Series Monitor Wells, TH-Series Monitor Wells, and Other Important Features at the Ormet Corporation Plant Site, Hannibal, Ohio.

Boreholes were drilled to depths ranging from 52 to 101 feet using conventional 3-1/2-inch I.D.(nominal 8-inch O.D.) hollow-stem augers. All boreholes were installed to bedrock, as designated by auger refusal. At all of the boring locations, drilling was completed without adding any fluid to the borehole, so as not to alter the quality of aquifer fluids.

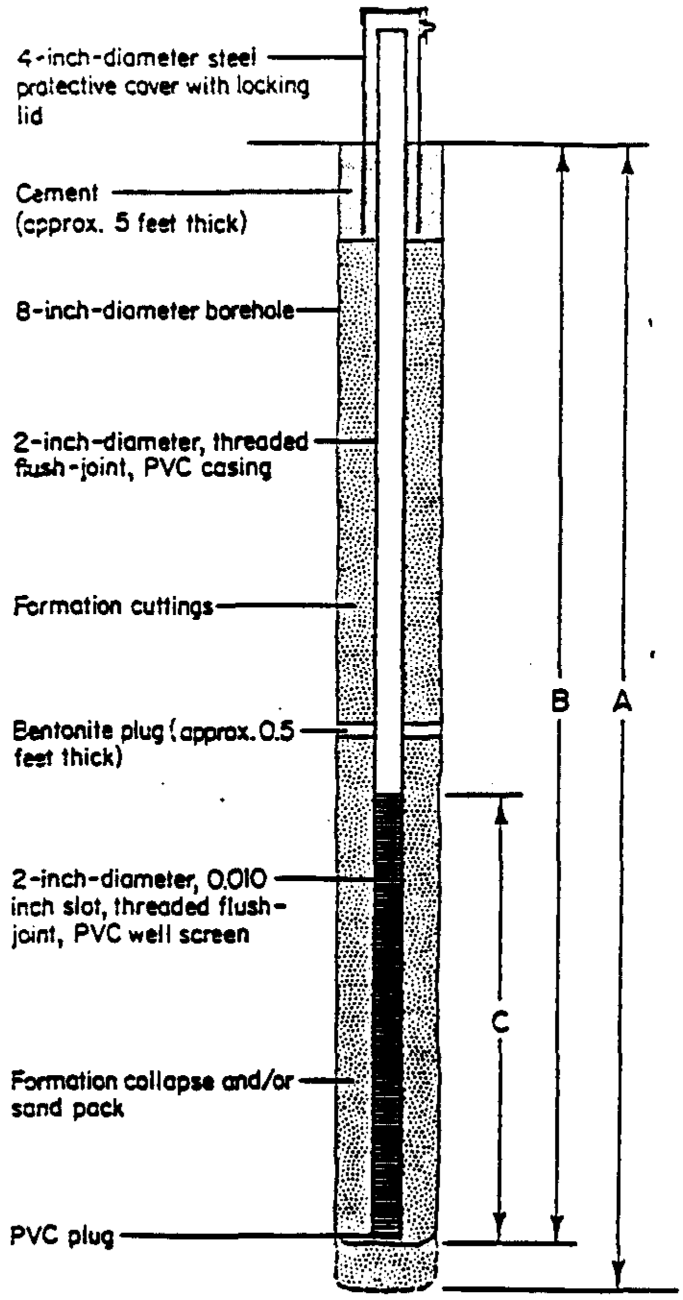
Core samples were taken at 5-foot intervals in all borings using an 18-inch-long, 2-inch-diameter split-spoon sampling device that was driven ahead of the lead-auger flight. Prior to collecting each core, the split-spoon sampler was washed to avoid cross-contamination between soil samples. All cores were inspected and described in the field by a Geraghty & Miller, Inc., representative. Lithologic descriptions of materials encountered during drilling are presented in Appendix A.

Two Shelby tube samples were collected during the drilling program, one at the MW-14 location (depth 35 to 37 feet), and the other at the MW-20 location (depth 15 to 17 feet). These samples, which were taken in silty-clay formation materials, were analyzed by Hardin-Kight Associates, Inc., for vertical permeability (Kv) using the falling-head permeability testing method. Also, four cation-exchange analyses were performed on selected core samples from boring locations MW-12, MW-13, MW-14, and MW-20. Soil testing results are presented in Appendix B.

Monitor-Well Installation and Development

With the exception of MW-6, all boreholes were converted to monitor wells which are used for water-level measurements and groundwater sampling. The monitor-well assemblies, which consist of 2-inch-diameter PVC casing coupled to bottom sections of 2-inch-diameter, 0.010-inch-slot, PVC well screen, were inserted through the inner bore of the hollow-stem auger flights. After the wells were in place, the augers were pulled allowing the formation materials to collapse in around the well screen. After all of the auger flights were pulled, enough sand was added to the boreholes to bring the sand pack to a level at least 10 to 15 feet above the top of the well screen, and a bentonite and/or bentonite and cement plug was installed to prevent seepage of surface fluids down the borehole.

The remaining annular space was then filled with formation cuttings up to about five feet below ground level, and a cement mixture was installed up to the land surface. Protective steel well covers were then placed over the monitor wells and seated into the cement. Figure 3 depicts general monitor-well construction; specific construction details for each monitor well are also listed at the end of their respective well logs presented in Appendix A.



Well No.	Approximate Dimensions A	B	C
MW-1	69	69	49 to 69
MW-2	86	84	54 to 84
MW-3	77	76	46 to 76
MW-4	94	74	54 to 74
MW-5	90	90	60 to 90
MW-6	52	No well installed	
MW-7	79	78	58 to 78
MW-8	98	98	68 to 98
MW-9	101	101	71 to 101
MW-10	100	100	70 to 100
MW-11	95	95	65 to 95
MW-12	67	67	27 to 67
MW-13	88	87	57 to 87
MW-14	86	86	46 to 86
MW-15	56	56	36 to 56
MW-16	84	81	46 to 81
MW-17	77	76	36 to 76
MW-18	59	59	39 to 59
MW-19	64	64	44 to 64
MW-20	65	64	34 to 64

Figure 3. General Monitor Well Construction at the Ormet Corporation Plant Site, Hannibal, Ohio.

All monitor wells were developed using an air compressor equipped with a 100-foot-long section of 3/4-inch-diameter plastic hose. Development times ranged from 25 to 105 minutes per well. The volume of fluid removed from each well varied from less than a few gallons to more than a few hundred gallons; additional development was also conducted prior to collecting groundwater samples.

Groundwater Sampling and Analysis

Two sets of groundwater samples were collected from monitor wells MW-1 through MW-20 for the purpose of water-quality analyses. Sampling was conducted during December 28, 29, and 30, 1983, and February 1, 2, 3, and 4, 1984. A complete round of water-level measurements were collected before the start of each sampling event; water-level data are presented in Appendix C-1. Prior to collecting each sample, approximately three well volumes of groundwater were evacuated from the well and field analyses for temperature, pH, and specific conductivity were conducted; results of field analyses are presented in Appendix D-1. Samples were then collected in one gallon polyethylene containers and kept chilled to a temperature at least as low as the ambient groundwater temperature.

Filtering and preservations were done at the end of each sampling day. For the initial set of samples, all filtering was performed using 0.45 micron membrane filters. However, owing to the consistency of aquifer fluids at several locations (MW-2, MW-5, MW-8, MW-11, MW-16, and MW-18), it was decided that more porous, fiberglass pre-filters would be used to remove suspended materials from the second set of samples collected at these wells; other second-set samples were filtered as before.

Non-filtered/non-fixed, filtered/HNO_3-fixed, and filtered/H_2SO_4-fixed sample fractions were prepared from the first set of groundwater samples. Second-set samples also included a filtered/NaOH-fixed fraction in an effort to preserve fluid constituents that precipitated under lowered pH conditions.

Water quality analyses were performed both by the Ormet Corporation laboratory and by Martel Laboratory Services, Inc., of Baltimore, Maryland. The parameters analyzed by each lab and the results of chemical analyses are presented in Appendix D-2.

SITE HYDROGEOLOGY CONDITIONS

Geology

The Ormet plant site is immediately underlain by unconsolidated deposits of sand, silt, silty to sandy clay, and pebbles, which rest unconformably upon a bedrock base. The approximate elevation and general configuration of the bedrock surface is depicted by the structure-contour map presented in Figure 4; bedrock elevation data is presented in Appendix E.

Throughout upper portions of the plant (away from the river), unconsolidated sediments consist predominantly of sand and pebbles, which are fairly continuous down to bedrock; depths to bedrock ranged from 50 to 100 feet. In lower plant areas (near the river) sand is generally overlain by silty to clayey floodplain deposits that form a wedge which thickens toward the Ohio River. Figures 5 through 10 depict general geologic trends beneath the Ormet site. Precise descriptions of lithologies encountered during drilling are presented in Appendix A.

Coarser soil materials (i.e., sand and pebbles) appear to be composed primarily of quartz and lesser amounts of feldspar minerals, as determined by visual inspection; thin

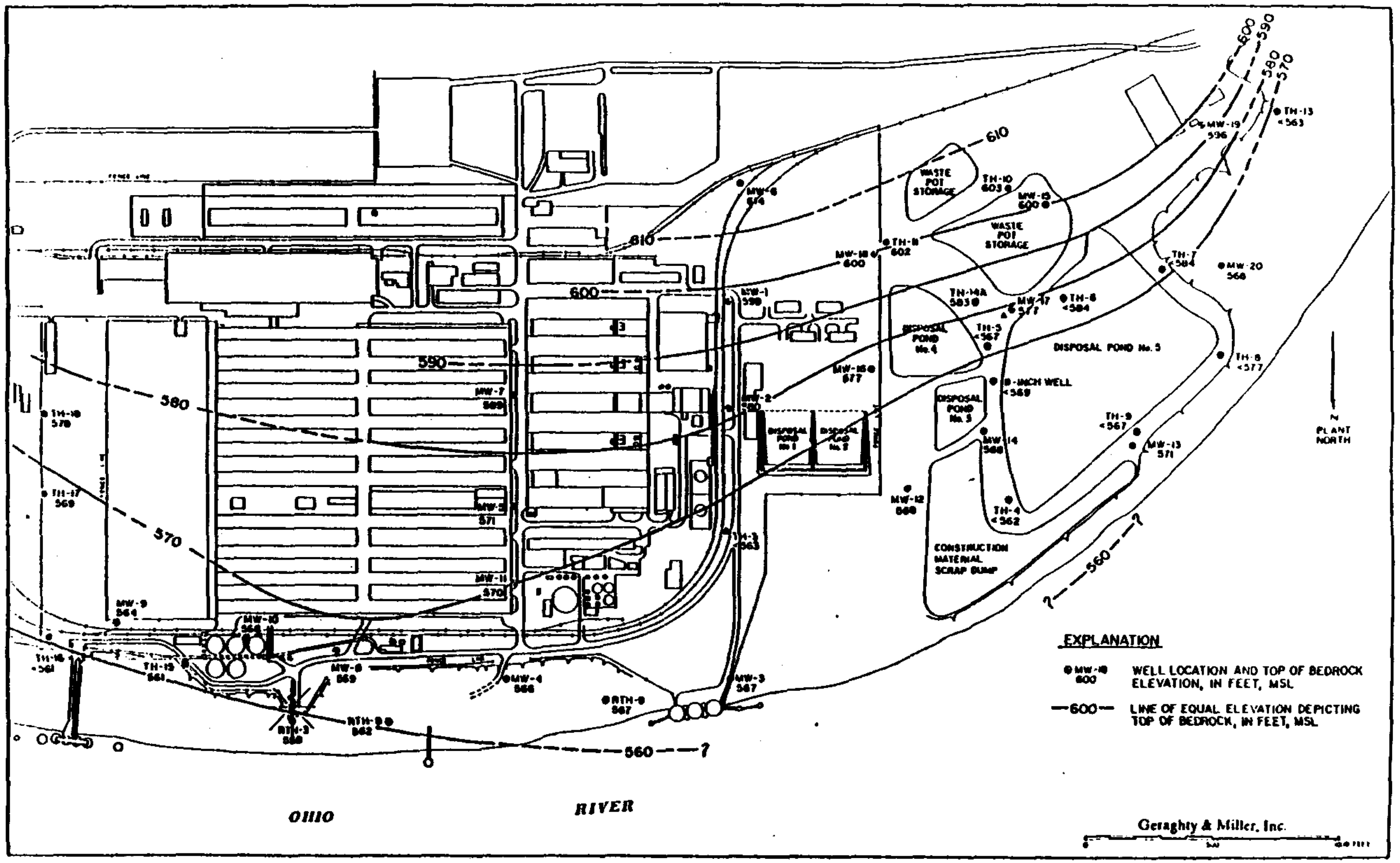


Figure 4. Structural-Contour Map Depicting Approximate Elevation and Configuration of the Bedrock Contact Beneath the Ormet Corporation Plant Site, Hannibal, Ohio.

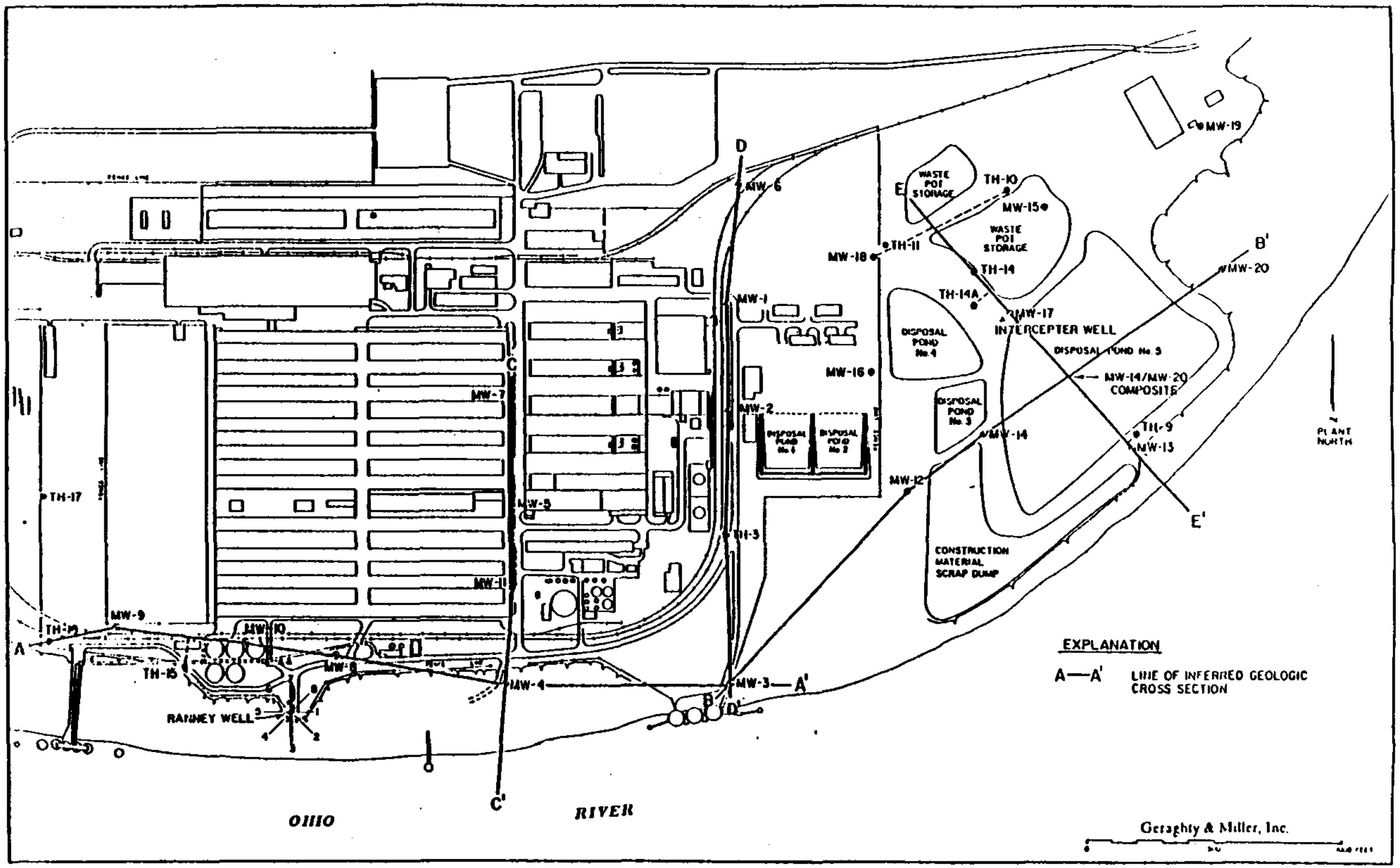


Figure 5. Geologic Cross-Section Reference Map, Ormet Corporation, Hannibal, Ohio.

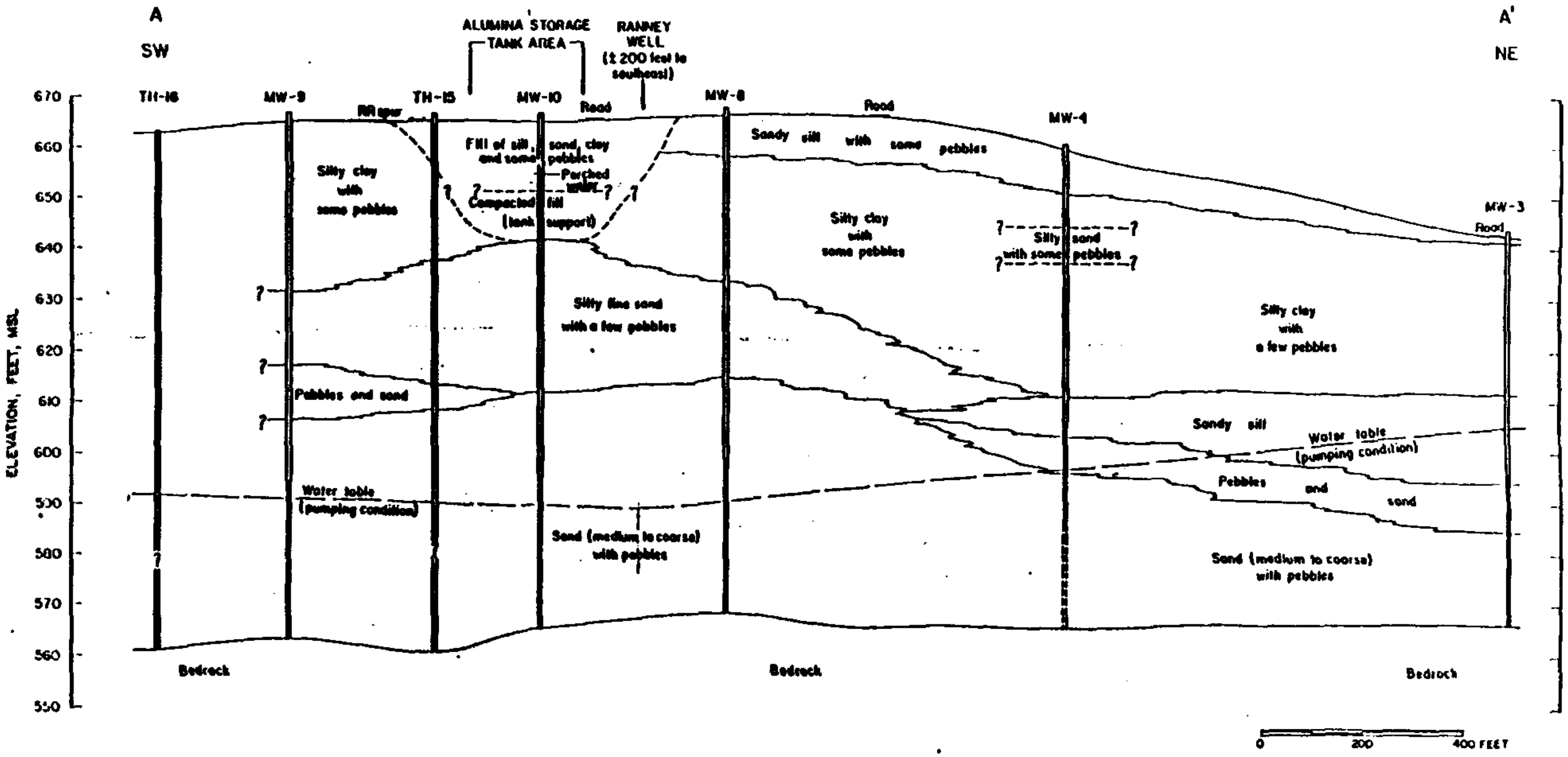


Figure 6. Inferred Geologic Cross-Section A-A', Ormet Corporation, Hannibal, Ohio.

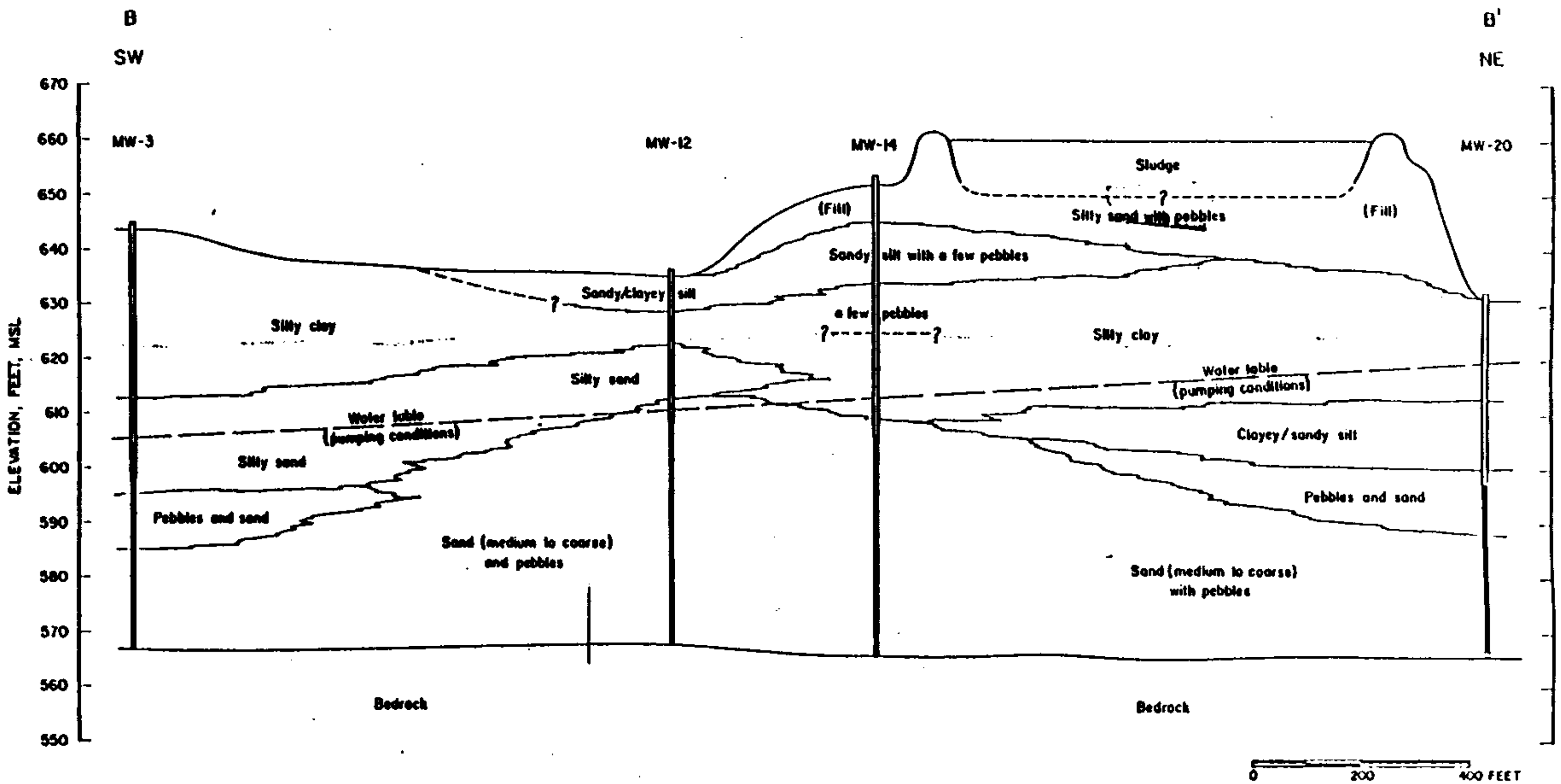


Figure 7. Inferred Geologic Cross-Section B-B', Ormet Corporation, Hannibal, Ohio.

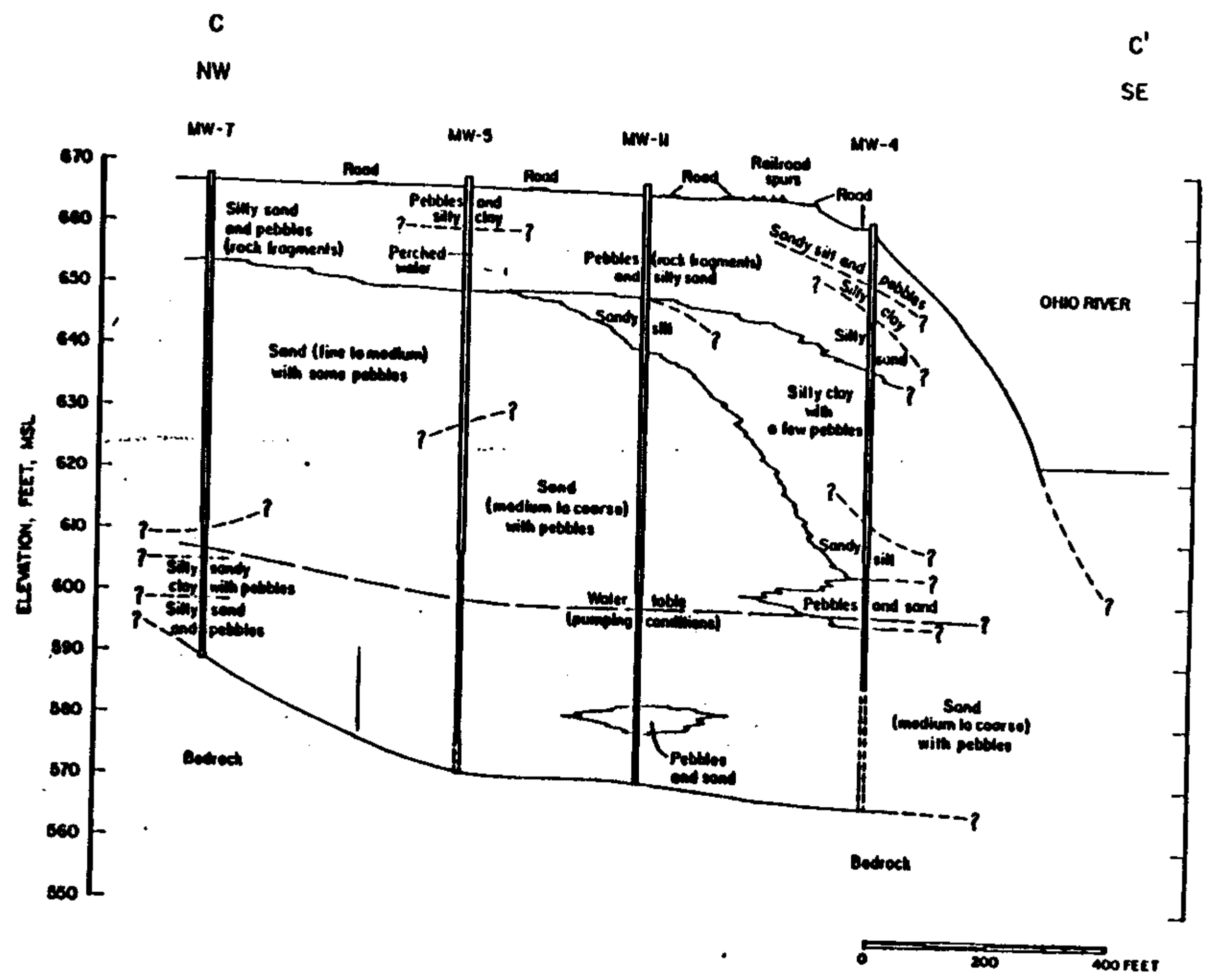


Figure 8. Inferred Geologic Cross-Section C-C', Ormet Corporation, Hannibal, Ohio.

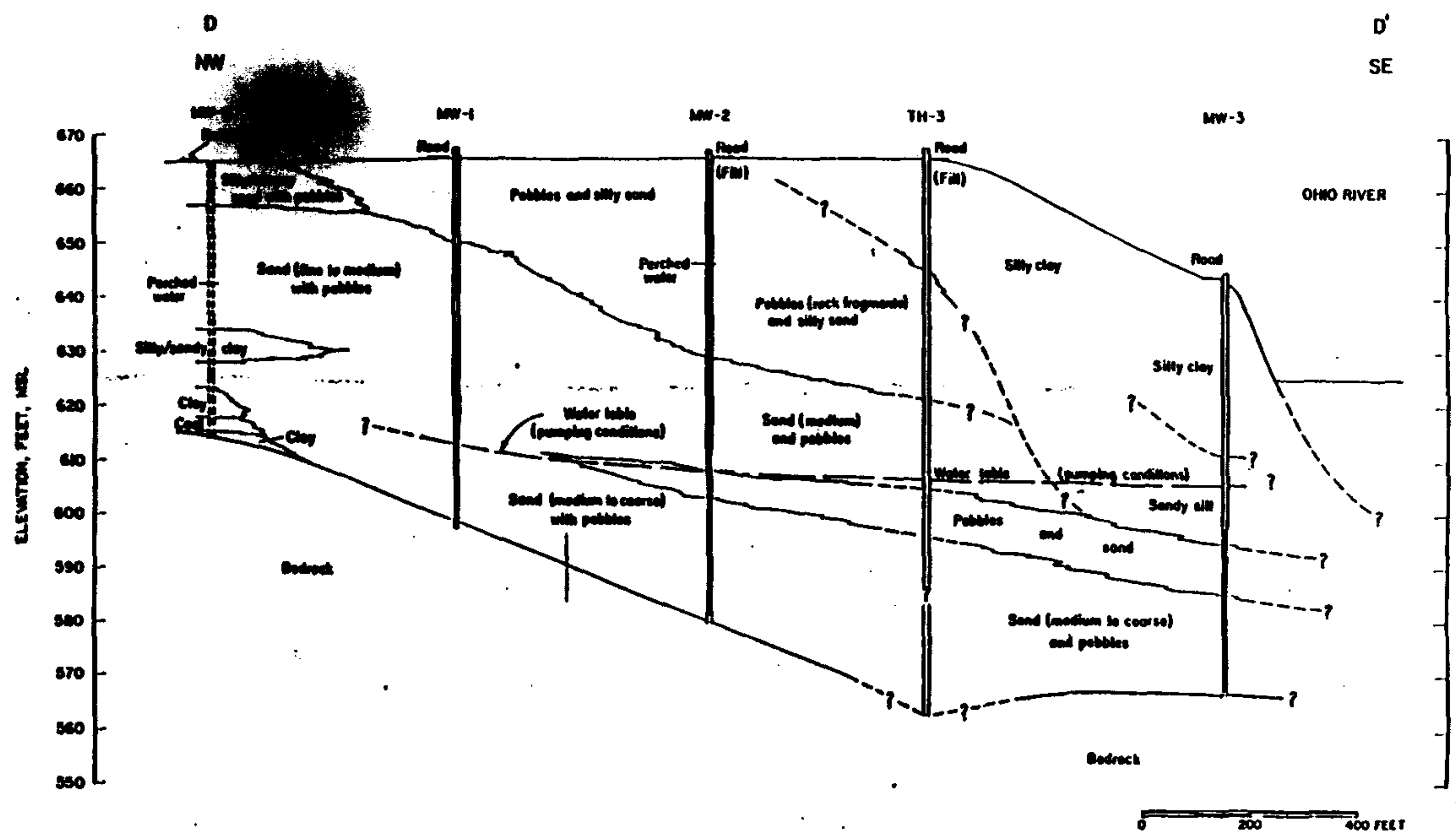


Figure 9. Inferred Geologic Cross-Section D-D', Ormet Corporation, Hannibal, Ohio.

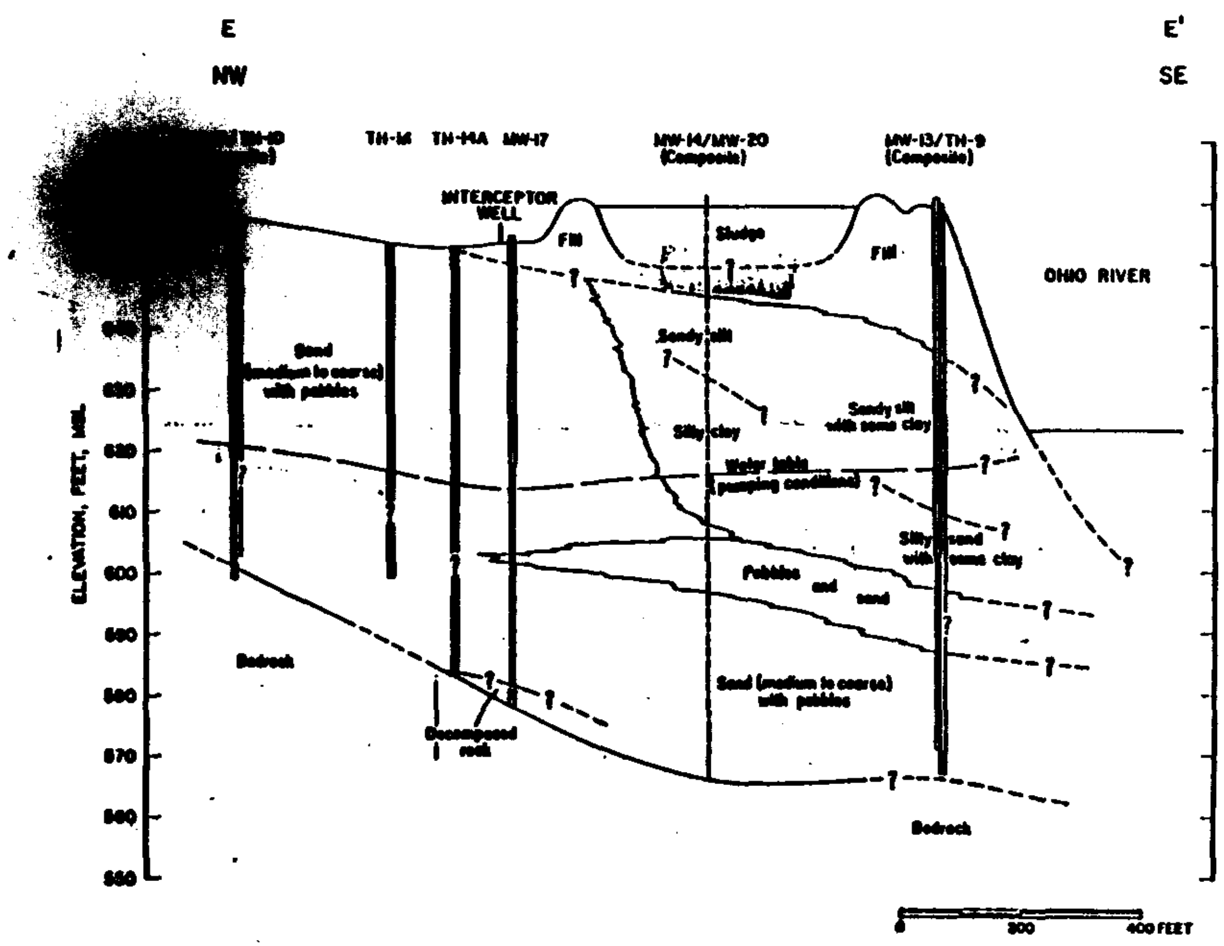


Figure 10. Inferred Geologic Cross-Section E-E', Ormet Corporation, Hannibal, Ohio.

layers of peat-type material are also common throughout these sediments. No laboratory tests were conducted to determine the mineralogy of finer soil fractions (i.e., clays and silts); however, the low-cation exchange capacities, 10 milliequivalents/100 grams or less, determined for clay-rich samples suggest that kaolinite [$Al_2Si_2O_5(OH)_4$] may be an important component (Garrels and Crist, 1965). Results of cation exchange analyses are included in Appendix B.

As noted in the preceding section, most of the sand and gravel materials comprising Buck Hill Bottom are thought to represent outwash that aggraded the Ohio River Valley during retreat of Pleistocene glaciers. Accumulations of finer sediments in areas adjacent to the Ohio River probably largely represent floodplain deposits remnant from more elevated river regimens.

Aquifer Characteristics and Groundwater Flow

Two types of water-bearing zones are present beneath the Ormet plant site: 1) discontinuous zones of perched groundwater, and 2) the Ohio River Valley water-table aquifer. Perched zones represent unconfined groundwater that is separated from the water table by an unsaturated zone. These zones were mostly encountered at shallow depths (20 feet or less) beneath the main plant facility, and are believed to, at least in part, result from storm drain leakage.

With the exception of MW-6 and MW-10 locations, perched zones appear to be very limited vertically, and may not actually represent a saturated condition, i.e., water may simply be enroute to the water table. The locations and depths of observed perched-water zones are indicated in Appendix A and on Figures 6 through 10.

The Ohio River Valley water-table aquifer is comprised primarily of sand and pebbles, and constitutes the main water-bearing unit in the area. The aquifer has been extensively developed within Buck Hill Bottom, and is presently yielding about six million gallons of water daily, most of which is being pumped from two Ranney wells (see Figure 1).

Data obtained from an aquifer-testing program conducted by Fred Klaer and Associates (1972), indicate that aquifer sediments typical of the central plant area are characterized by a coefficient of transmissivity (T) of about 60,000 gpd/ft and a coefficient of permeability (k) of about 1900 gpd/ft^2 (or a hydraulic conductivity, K, of about 10^{-1} cm/sec). The coefficient of storage is calculated to be about 0.19 (dimensionless).

Using the K value of 10^{-1} cm/sec, a hydraulic gradient (I) of 0.008 to 0.009 ft/ft, and an assumed effective porosity (n) of 0.25 (dimensionless), it is estimated that groundwater beneath northeast parts of the plant area is moving toward the Ormet Ranney well at a rate (V) of about 9 to 10 feet per day (about 3300 to 3700 feet per year); by equation $V = \frac{KI}{n}$. Based on these flow velocities, groundwater traveling beneath the storage and disposal facilities should reach the Ormet Ranney well within about a year's time. Travel times for dissolved groundwater constituents may be (probably are) somewhat slower, depending upon the net retardation factor for a particular constituent.

Flow velocities calculated by Geraghty & Miller, Inc., are roughly four times faster than flow velocities calculated by Fred Klaer (1972). This difference results from omission of the effective porosity factor in Fred Klaer's calculations; it is believed that faster estimated flow rates probably more accurately reflect actual conditions.

Prior to development of the aquifer (before 1956), the water table probably sloped from north to south with groundwater flowing toward and discharging into the Ohio River. Pumping from Ranney wells has caused the water table to drop below the level of the river. As a result, water is now being pulled from the river into the aquifer, and is flowing in the direction of pumping centers (i.e., toward Ranney and interceptor wells).

The inferred water-table contour maps presented in Figures 11 and 12 generally depict how past and present pumping has affected groundwater flow patterns beneath Buck Hill Bottom. As can be partly seen, groundwater withdrawals have created two large cones of influence which converge to form a gently rounded crest, or drainage divide, that is situated roughly parallel to Ormet's west property boundary. Water-level data used to construct these maps are presented in Appendix C.

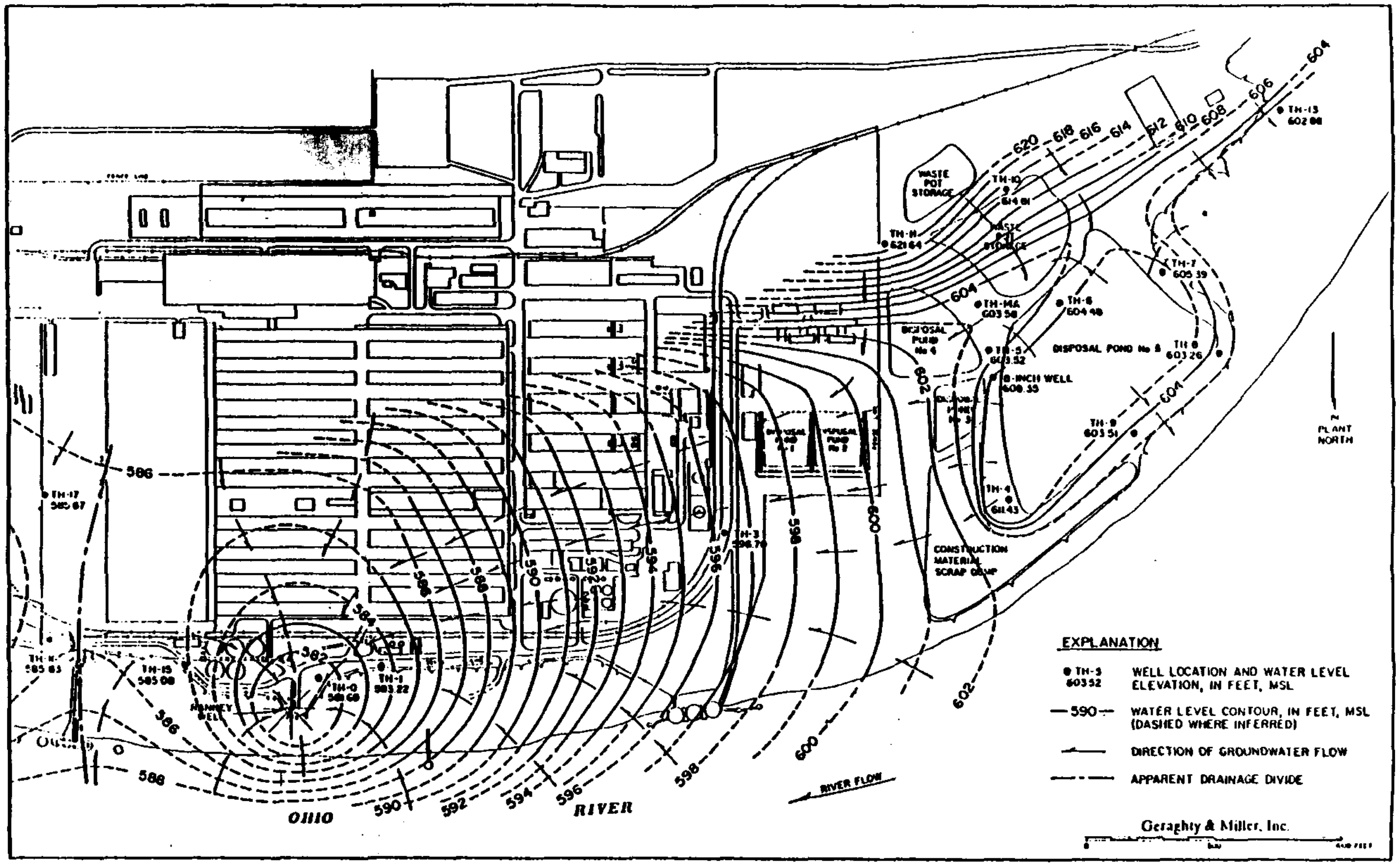


Figure 11. Inferred Water-Table Contour Map Depicting Past Conditions at the Ormet Corporation Plant Site, Hannibal, Ohio.
(Based on median values of 1972 water-level data)

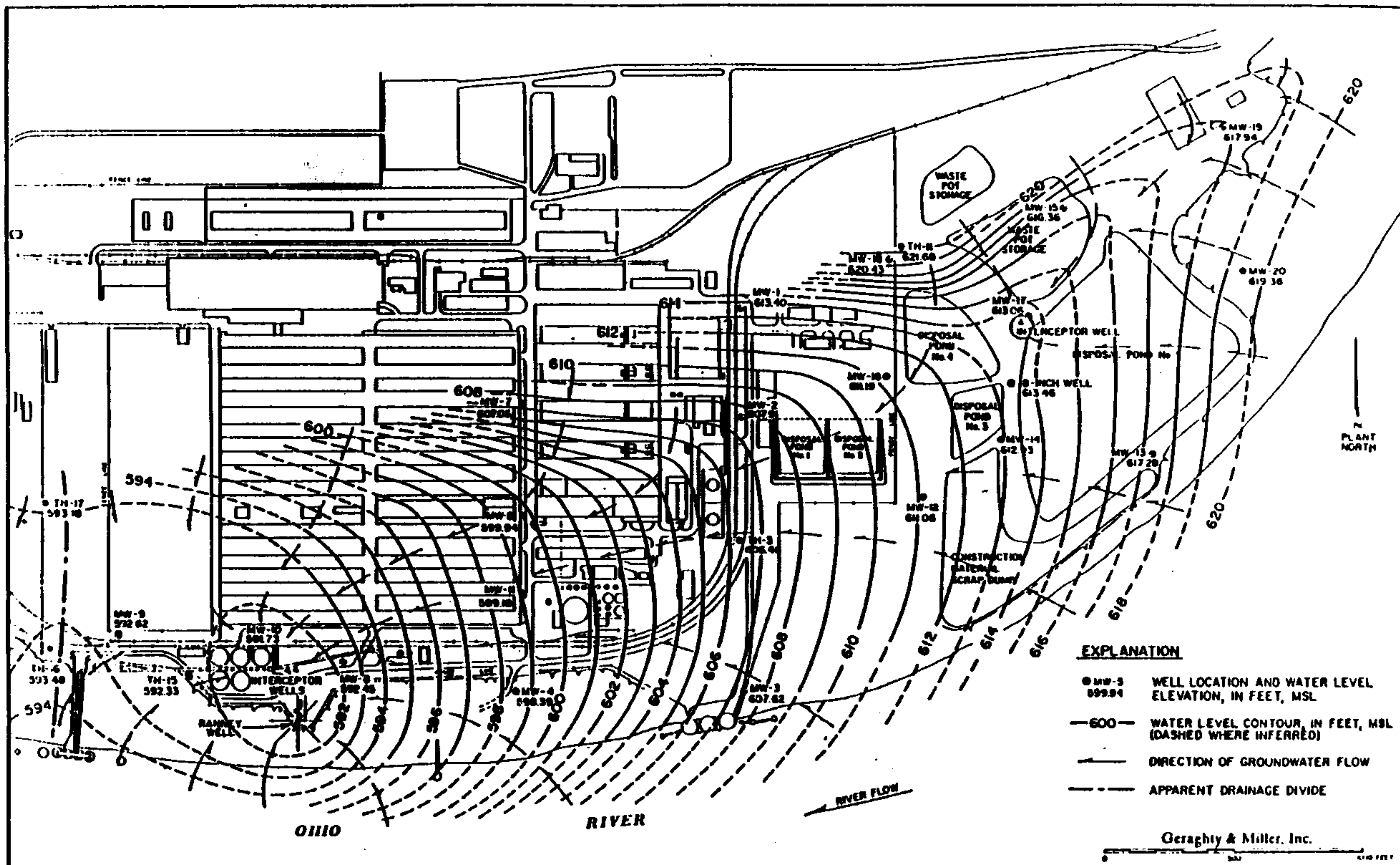


Figure 12. Inferred Water-Table Contour Map Depicting Present Conditions at the Ormet Corporation Plant Site, Hannibal, Ohio.
(Based on 01/31/84 water-level data)

Figures 11 and 12 also reflect conditions before and after closing of the Hannibal Lock and Dam in 1973, which caused roughly a 20-foot rise in river-pool elevation. Aside from an overall rise in groundwater levels (more than 10 feet in the area of the disposal ponds and more than 5 feet in the vicinity of Ormet's Ranney well) the rise in river-pool elevation does not appear to have greatly changed the configuration of the water-table aquifer under pumping conditions. Damming the river probably has caused an increase in silt accumulation along the bottom, which some authors suggest may be reducing the capacity for river recharge of the water-table aquifer. Although silting may cause some reduction in the permeability of subjacent deposits, the overall increase in saturated aquifer thickness suggests that increased hydraulic heads (from the rising river) have more than compensated for any such reductions; and the water-table aquifer appears to be potentially more productive as a result of increasing the river pool elevation, barring overall decreases in aquifer permeability.

To the northwest of disposal pond No. 5 (near TH-10 and, particularly, near TH-11), relatively little change in water-table elevation appears to have resulted from raising the river pool. This is probably because these wells are situated more toward the valley wall, where rising bedrock deposits (Figure 4) support a water table that, although hydraulically connected to the main aquifer body, is considerably less susceptible to pumping (drawdown) stresses; i.e., this portion of the water-table aquifer is sustained primarily by precipitation recharge which, given the aquifer's limited capacity to transmit water vertically and laterally, is sufficiently plentiful to maintain a relatively elevated body of groundwater. Owing to this condition, wells TH-10, TH-11, and MW-18, draw from a portion of the water-table aquifer that receives recharge emanating primarily from the north; and, these monitor wells appear to be situated hydraulically upgradient from all of the disposal ponds.

It is, therefore, reasonable to assume that groundwater-quality alterations that may be observed at these locations are probably mainly attributable to past potliner storage practices, barring the presence of heretofore unidentified source areas. Although somewhat less certain, current groundwater flow patterns further suggest that monitor wells MW-2, MW-16, and possibly other wells, may also be situated in areas that receive recharge emanating primarily from the north.

It is important to note that 1972 water-level data (Figure 11) imply a considerable degree of fluid mounding beneath the No. 5 disposal pond; whereas, 1984 data (Figure 12) do not indicate the presence of a discernible mound. This change probably mainly reflects retirement of the No. 5 pond in 1981, when the cryolite recovery plant was closed and sludge disposal practices were discontinued.

Under present pumping conditions, the water-table aquifer is receiving recharge both from the Ohio River and from infiltrating precipitation; relatively minor amounts of recharge may also issue from inactive disposal ponds. Based on estimates by Fred Klaer and Associates (1972), 90 percent or more of the 6 mgd being pumped from the alluvial aquifer is probably derived through induced recharge from the Ohio River. As a result, there does not appear to be any natural discharge of groundwater into the Ohio River along most of the river/plant boundary.

GROUNDWATER QUALITY

Past Cause-and-Effect Relationships

Starting in 1958, when the Ormet plant began operation, spent cathode material (i.e., potliner) was accumulated in several areas to the northeast of the plant site, and surface impoundment facilities (ponds No. 1 through 5) were used for the disposal of wet scrubber sludges (see Figure 2 for locations). In general, potliner wastes consist of carbon-based material with impurities which, upon weathering, produce an alkaline leachate containing parameters such as fluoride, cyanide, sodium, and ammonia; and scrubber sludge consisted mainly of calcium-based salts including $CaSO_4$, CaF_2, and $Ca(OH)_2$, as well as Na_3AlF_6.

In August 1968, Ormet started operating a cryolite recovery plant, and the (then active) No. 5 disposal pond began to receive very alkaline sludge consisting of sodium-based salts including NaF, Na_2SO_4, Na_2CO_3, Na_3AlF_6, and $NaAlO_2$, as well as $Ca(OH)_2$ and $CaCO_3$; this material was placed on top of the older calcium-based compounds. Based on available data, it appears likely that this change in the disposal process was largely responsible for changes in Ranney well water quality that became apparent in July 1971; i.e., the well began to produce alkaline, discolored water.

The deteriorated quality of water produced from the Ranney well prompted a site hydrogeologic study by Fred Klaer and Associates (during 1972), which involved the installation of some 20 monitor wells (TH-series) to assess water-quality conditions and groundwater flow patterns (see Figure 2 for well locations). Resultant data indicated that fluid was mounded beneath the No. 5 disposal pond and groundwater was being pulled from storage and disposal areas toward the Ormet Ranney well (Figure 11). Data also indicated that virtually all of the wells located in the vicinity of, and hydraulically downgradient from the No. 5 disposal pond (i.e., TH-3, TH-5 through TH-9, TH-14A, and 8-Inch) showed substantial degrees of water-quality degradation by parameters that appeared to be closely related to pond effluents; the quality of water sampled at the TH-10 and TH-11 locations did not show an appreciable degree of alteration at this time (see Appendix D-3 for water-quality data from TH-series wells). As an interim solution, two interceptor wells were eventually installed (12/72) several hundred feet north of the Ranney well to intercept the plume of discolored groundwater before it reached this pumping center.

In 1976, Ormet began to neutralize sludge from the cryolite recovery plant prior to discharge into the No. 5 disposal pond. This process change appears to have significantly reduced water-quality impacts resulting from pond seepage; as evidenced by a supplemental study conducted by Dames and Moore (1977 to 1978), which demonstrated a considerable improvement in the quality of groundwater sampled from wells that still existed in the vicinity of the No. 5 disposal pond. However, groundwater sampled at the TH-10 and TH-11 locations may have become slightly more affected than it was in 1972. Comparisons of 1972 and 1978 water-quality data are presented in Table 1.

In October 1981, the cryolite recovery plant was shut down and sludge disposal practices were discontinued. Shortly before this time, a plant clean up effort was also initiated, whereby, spent cathode and other debris accumulated in the potliner storage areas were hauled away; however, it is likely that equipment used in the clean up effort broke and crushed some quantity of potliner material,

TABLE 1.
COMPARISONS OF WATER-QUALITY DATA COLLECTED FROM TH-SERIES MONITOR WELLS AT THE ORMET CORPORATION PLANT SITE, HANNIBAL, OHIO

SAMPLE LOCATION	DATE	GALLONS PUMPED	CASING VOLUME	FLUORIDE (mg/l)	DISSOLVED SOLIDS (mg/l)	HARDNESS (mg/l)	TRANSMITTANCE (%)	pH	CHLORIDE (mg/l)	CYANIDE* (mg/l)	AMMONIA (mg/l)
8" Well	1972 Range	—	—	260-1100	—	—	0-96	10.1-10.9	2766-4100	—	--
	08-25-78	166.8	16.8	64.8	3,500	65	24	8.8	80	<0.01	0.00
	11-09-78	—	12	62.3	2,200	—	11	8.7	—	0.02	0.06
Well TH-3	1972 Range	—	—	150-468	—	—	0-89	9.2-10.1	390-443	—	--
	08-25-78	378.0	8.8	9.9	500	100	91	9.1	39	0.01	0.00
	11-09-78	—	12	11.5	600	125	83	8.9	59	0.01	0.17
	01-84	—	3	1.5	—	—	96	7.5	--	0.41	--
	02-84	—	3	3.4	—	—	—	7.4	36	0.16	0.00
Well TH-7	1972 Range	—	—	250-364	—	—	0	9.8-10.0	—	--	--
	08-29-78	66.0	4.2	34.4	700	40	9	7.9	43	<0.01	2.10
Well TH-10	1972 Range	—	—	0.9-10.0	—	—	2-98	7.2-8.1	128	--	--
	11-09-78	—	2.4	43.4	1,500	—	0	7.9	--	0.00	0.00
Well TH-11	1972 Range	—	—	1.4-10.1	—	—	0-95	6.9-7.9	117-142	—	—
	08-28-78	18	1	8.6	500	120	15	6.6	51	—	0.49
Well TH-15	1972 Range	—	—	1.0-2.7	—	—	87-99	7.2-8.2	21-32	—	--
	12-01-78	198.5	8.3	2.7	—	—	—	7.3	—	—	--
	01-84	—	3	<1.0	—	—	95	7.4	—	0.03	--
	02-84	—	3	1.0	—	—	—	7.5	43	<0.01	0.00
Well TH-16	1972 Range	—	—	1.0-1.8	—	—	90-99	7.9-8.6	27	—	--
	11-09-78	—	4.6	0.7	300	165	100	7.7	30	0.00	1.02
Well TH-17	1972 Range	—	--	0-0.24	—	—	30-99	7.3-7.9	34-39	--	--
	08-28-78	159.0	5.3	<0.2	500	255	100	7.3	43	0.01	0.00
	11-09-78	—	2.05	<0.2	400	260	100	7.3	42	0.00	0.00

*1984 Concentrations reflect total cyanide; 1978 concentrations may represent free cyanide.

Note: 1972 data collected during Fred Klaer and Associates study; 1978 data collected during Dames & Moore study; 1984 data collected during Geraghty & Miller, Inc., study. All chemical analyses were performed by the Ormet Corporation laboratory.

which probably remains within the upper few feet of soil beneath this area. One could reasonably speculate that such a change in the consistency of potliner wastes should make this material more susceptible to leaching; i.e., crushing increases specific surface area, which, for a given volume of material, exposes relatively greater quantities of soluble components.

In March 1982, a third interceptor well was also installed adjacent to the southwest corner of the No. 5 disposal pond in an effort to collect degraded groundwater before it migrates toward the Ormet Ranney well. This well is currently pumped at several hundred gallons per minute, which is discharged to the No. 5 disposal pond overflow. Fluid pumped from the well is alkaline, tea to coffee colored, and contains fluoride and cyanide. Averaged water-quality data (1982 to 1983) for the new intercepter well, the old intercepter wells (collectively regarded as one well), and the Ormet Ranney well are presented in Appendix D-4.

In the time since the Ormet Ranney well was installed, a gradual decrease in well yield has become apparent. Initially, this may have been largely due to carbonate incrustation or siltation; however, recent decreases (since discolored water began entering the well) are largely attributed to varying degress of incrustation by dark, medium to hard material, which has been observed in well laterals 5 through 8 (Ranney Company, 1982). Decreases in old interceptor well yields have also occurred, and are attributed to similar causes. One possible explanation for the apparent increase in well screen incrustation is that, upon reaching the pumping center, mixing of high pH plume fluids with relatively unaffected groundwater probably results in a net lowering of pH. This pH reduction may cause certain plume constituents (e.g., silica, aluminum, organic carbon) to become less soluble which, in turn, results in precipitation (incrustation) at the well screen and within adjacent sediments; a more detailed discussion of this phenomenon is presented in future sections. In addition, certain dissolved constituents within unaffected groundwater (e.g., calcium), which become less soluble under higher pH conditions, may also precipitate as a result of fluid mixing.

<u>Current Water-Quality Trends</u>

Chemical analyses of recently collected (1983-1984) groundwater samples suggest that former potliner storage areas and sludge disposal ponds (particularly Pond No. 5) both continue to contribute inorganic constituents to the water-table aquifer system. However, compared to 1972 groundwater conditions, there appear to have been significant reductions in water-quality alterations resulting from disposal pond seepage, and apparent increases in water-quality changes by potliner-related effluents. Results of recent (1983-1984) and past (1972) chemical analyses are presented in Appendices D-2 and D-3, respectively.

The most reliable parameters for ascertaining the presence of potliner and/or disposal pond effluents primarily include fluoride, cyanide, sodium, and elevated pH; and to a lesser extent, chloride, bicarbonate, carbonate, sulfate, iron, aluminum, and probably ammonia. Elevated concentrations of silica and total organic carbon (TOC), and reduced light transmittance are also generally characteristic of relatively affected groundwater; high-pH conditions increase the solubility (and concentrations) of silica and organic carbon species (derived from natural aquifer matrix materials), which, in dissolved and/or colloidal forms, are believed to cause discoloration that reduces light transmittance. Concentration versus pH trends for silica and TOC are presented in Figures 13 and 14, respectively. As can be seen, there is a strong positive

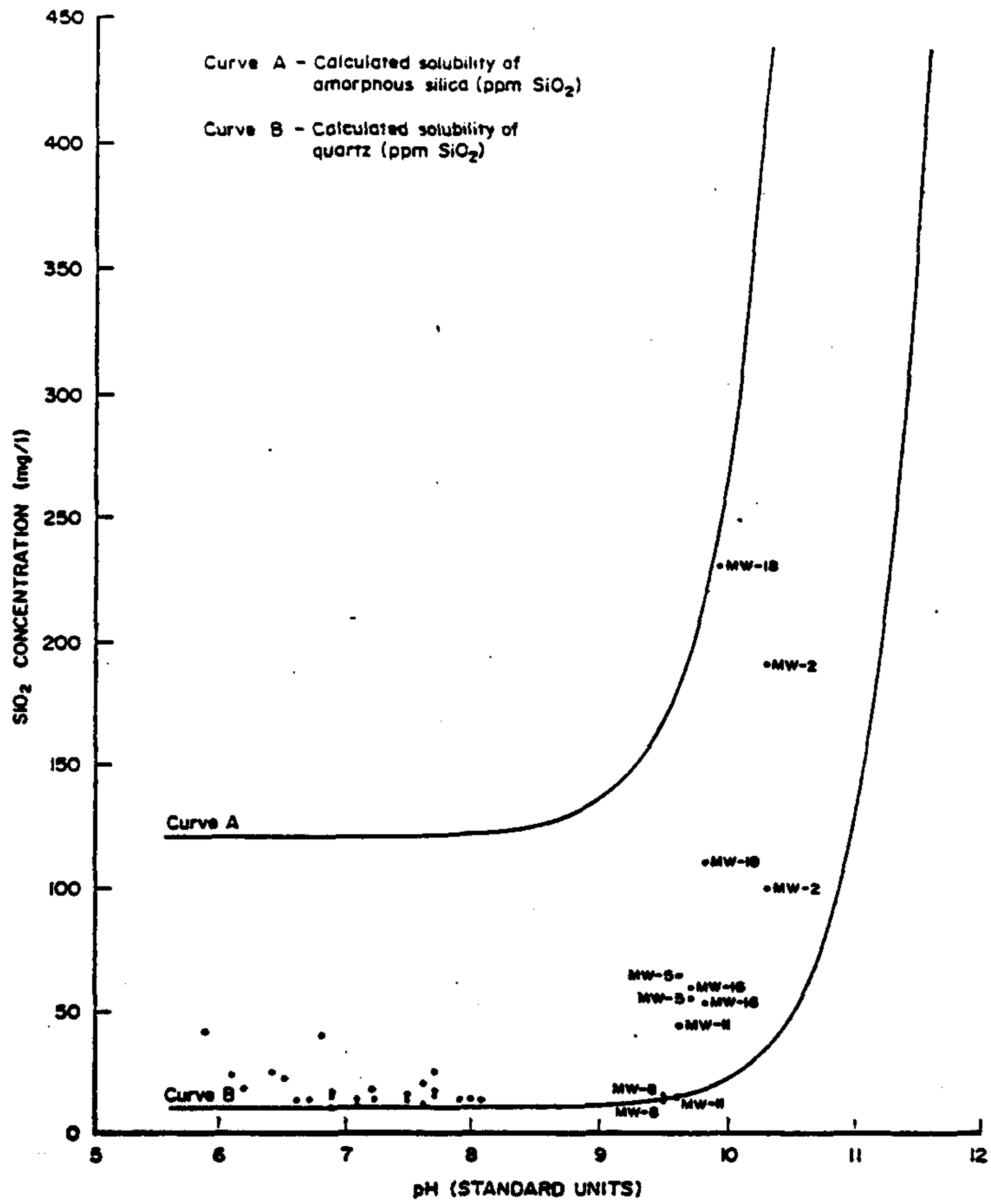


Figure 13. Silica Concentration Versus pH Trends, Ormet Corporation, Hannibal, Ohio.

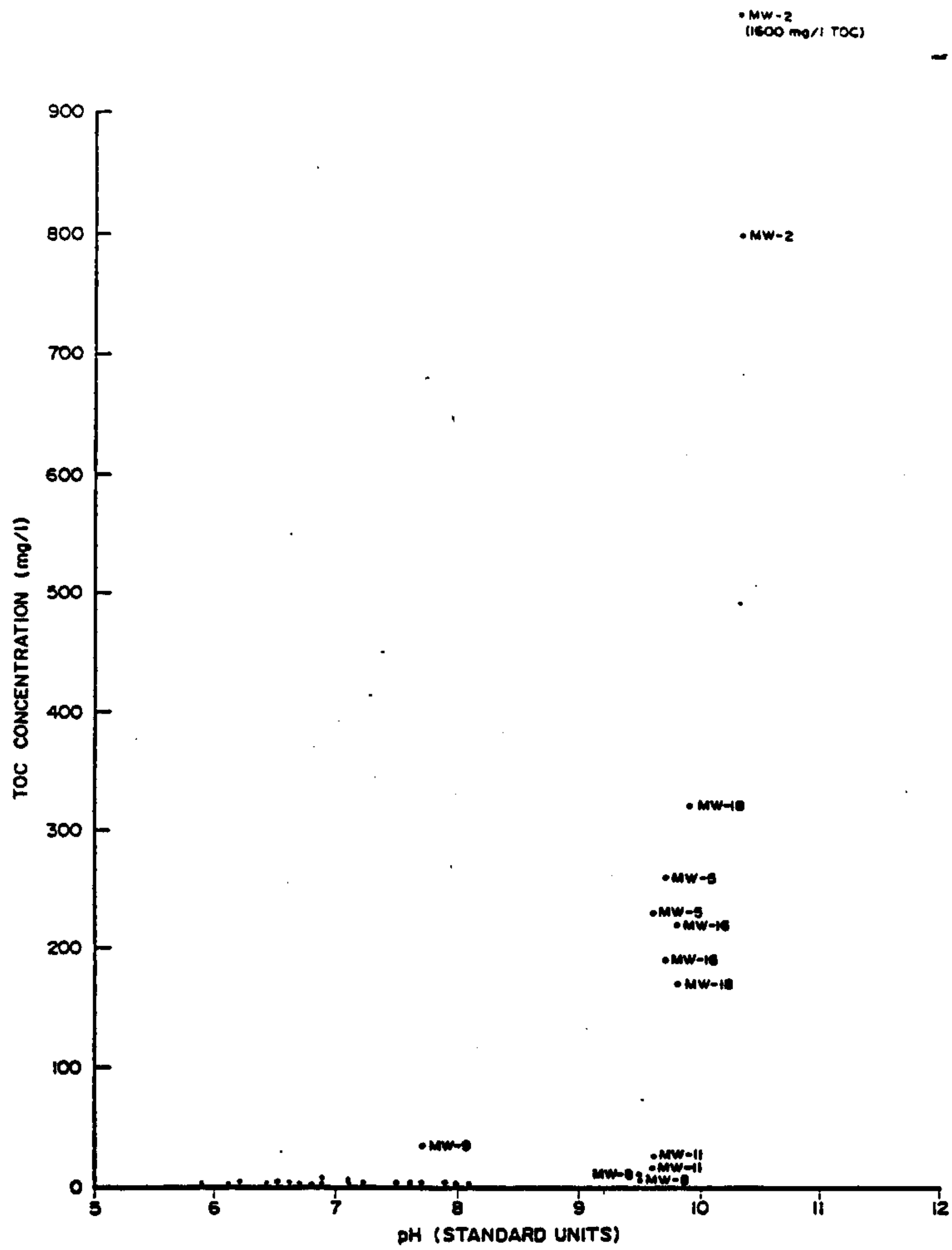


Figure 14. TOC Concentration Versus pH Trends, Ormet Corporation, Hannibal, Ohio.

correlation between high pH and increasing concentrations of these parameters.

Monitor wells MW-2, MW-5, MW-8, MW-11, MW-16, and MW-18 are most noticeably affected by the presence of extraneous groundwater constituents. Other wells, MW-9, MW-10, MW-13, MW-14, MW-15, MW-17, and TB-3 also exhibit one or more water-quality traits indicative of potliner and/or disposal pond-related effluents, although these wells show little or no water discoloration, and concentrations of observed seepage indicator parameters are relatively low.

Because the leachate generated within potliner storage areas, and the sludge placed into the No. 5 disposal pond (between 1968 and 1976) appear to be characterized by very similar chemical qualities, it would be difficult to validly credit groundwater quality impacts to either practice, based solely on the chemical makeup of effluents. However, groundwater flow patterns inferred from past and recent water-level data (Figures 11 and 12) indicate that deteriorated water quality observed in monitor wells TH-10, TH-11, MW-18, and possibly MW-2, MW-16, and other monitor wells has resulted primarily from leachate generation within the potliner storage areas, whereas, past and/or present water-quality alterations in wells TH-3 through TH-9, 8-Inch, MW-12, MW-13, MW-14, and possibly other wells are mainly the result of sludge disposal practices. Discolored water and high pH previously observed in some of the TH-series wells are believed to be mostly related to practices conducted between 1968 and 1976, when the No. 5 disposal pond received alkaline, non-neutralized sludge (pH 10 to 11).

Although adequate data are not currently available, it may be possible to more conclusively attribute observed water-quality trends to either practice, based on groundwater temperature trends. As can be seen on Figure 12, much of the groundwater passing beneath disposal pond facilities appears to originate as induced river recharge, whereas, groundwater moving beneath the potliner storage areas is probably replenished mostly by precipitation recharge. Because surface-water bodies (in this region) undergo a considerable degree of seasonal temperature variation, it follows that portions of an aquifer receiving recharge from these bodies should also experience seasonal fluctuations in groundwater temperatures; although some lag period is expected and temperature differences will probably be somewhat less extreme. However, shallow aquifers being recharged primarily by precipitation tend to exhibit relatively consistent groundwater temperatures throughout the year, which are generally fairly closely approximated by the average annual air temperature, roughly 53°F (12°C), in this area. Consequently, long-term (at least one year) monitoring of groundwater temperature trends may represent an additional means by which contaminant/source-area relationships can be more accurately defined.

The inferred plume boundary map presented in Figure 15 depicts the approximate extent and general migration of leachate plumes beneath the Ormet plant site. These delineations are mainly based on the water-quality data presented in Appendix D-2, and on groundwater flow patterns indicated in Figure 12. Some boundaries, particularly those shown by a dotted line, have also been surmised based on the expected remnants of past water-quality conditions, as represented in Appendix D-3.

As can be seen, Plume Section "A", which contains relatively high levels of leachate-related effluents, appears to originate mostly in the vicinity of former potliner storage areas; whereas, Plume Section "B", which is characterized by much lower concentrations of leachate indicators, seems to be more closely related to the No. 5 (and possibly other) disposal ponds. Plume Section "C",

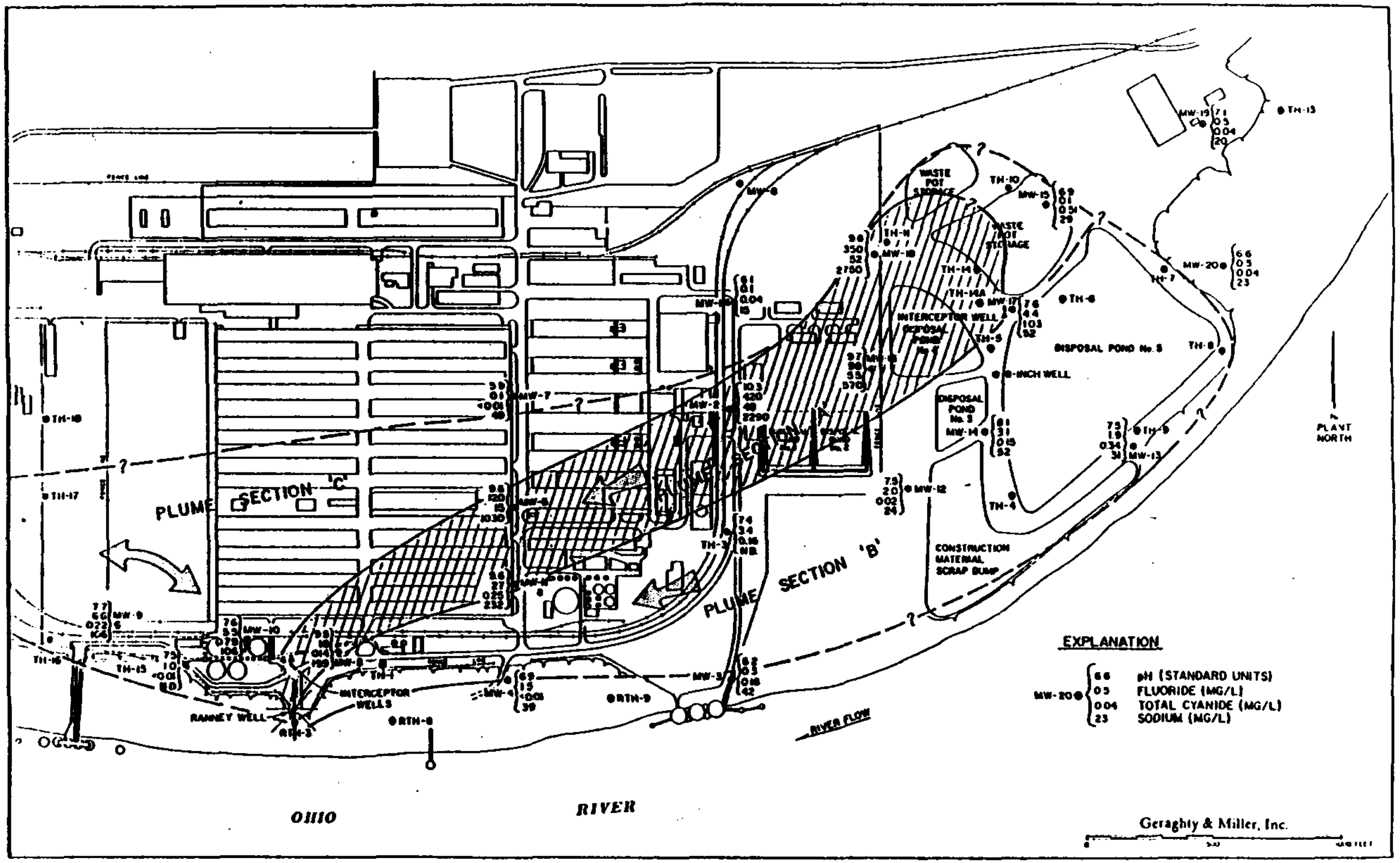


Figure 15. Inferred Leachate-Plume Boundary Map, Ormet Corporation, Hannibal, Ohio. (Based on 02/84 water-quality data)

located beneath the western portion of the plant site, also contains fairly low levels of leachate indicator parameters, and is believed to be a result of interrupted pumping at the Ormet Ranney well, which may have allowed intermittent shifting of leachate plumes (A and/or B) to the west.

A more detailed (and more speculative) assessment of Plume "A" conditions is presented in Figures 16 through 19. Based on these interpretations, it appears that levels of primary leachate indicators (i.e., pH, F, CN, and Na) are highest in the vicinity of former potliner storage areas, and become reduced as the distance from the source increases. It is likely that some quantity of leachate is continually being generated from this area, and that concentration versus distance trends characterizing these plumes are probably largely controlled by groundwater dilution or other attenuation mechanisms (e.g., sorption and natural buffering). However, it is also likely that rates of leachate generation have been periodically increased as a result of excavation and other disturbances within this area (such as the cleanup effort in 1981), and concentrated "slugs" of effluent may have been introduced to the aquifer system. Consequently, plume concentration trends could also reflect fairly recent increases in the rate of leachate

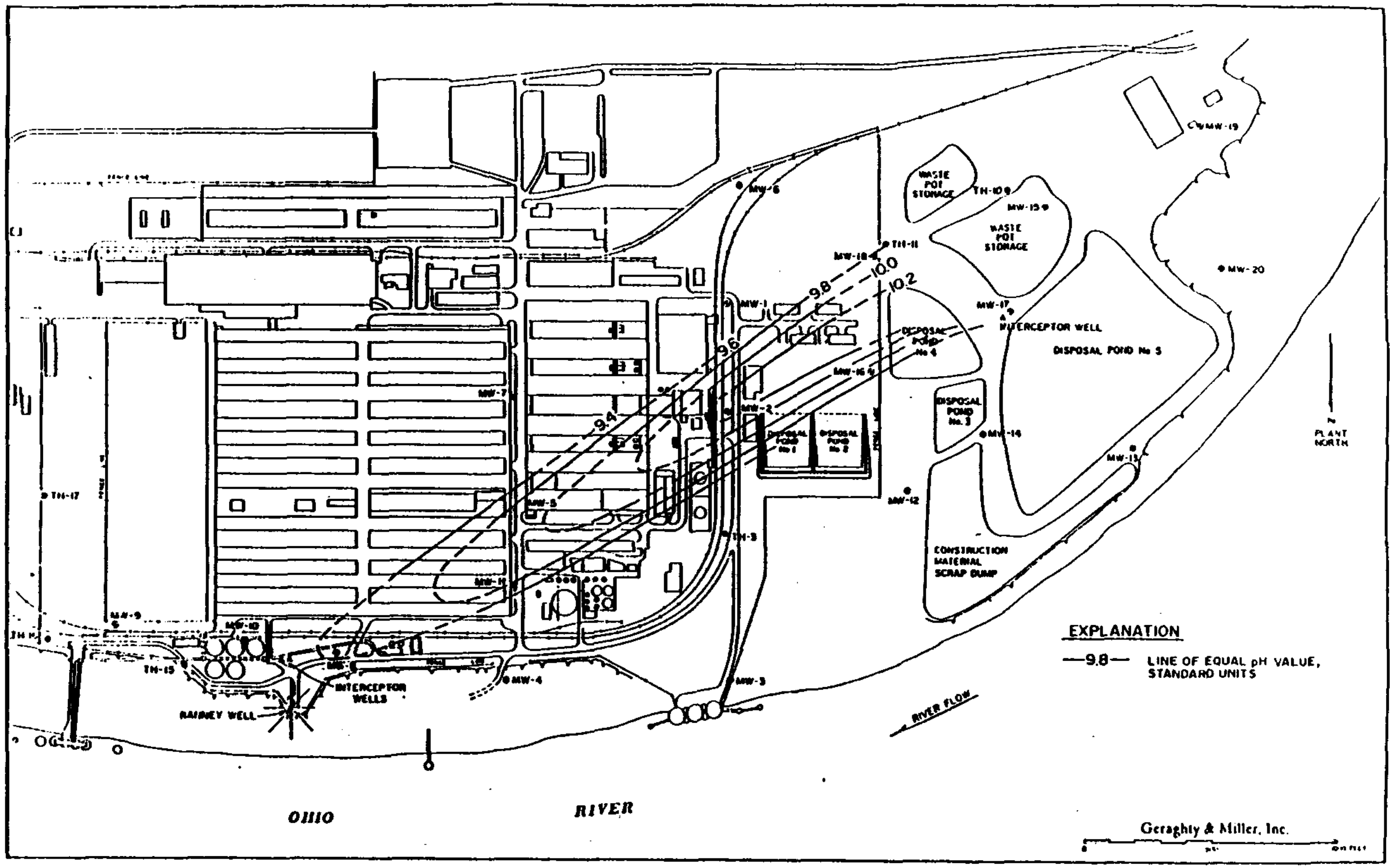


Figure 16. pH Isopleth Map, Ormet Corporation, Hannibal, Ohio. (Based on 02/84 water-quality data)

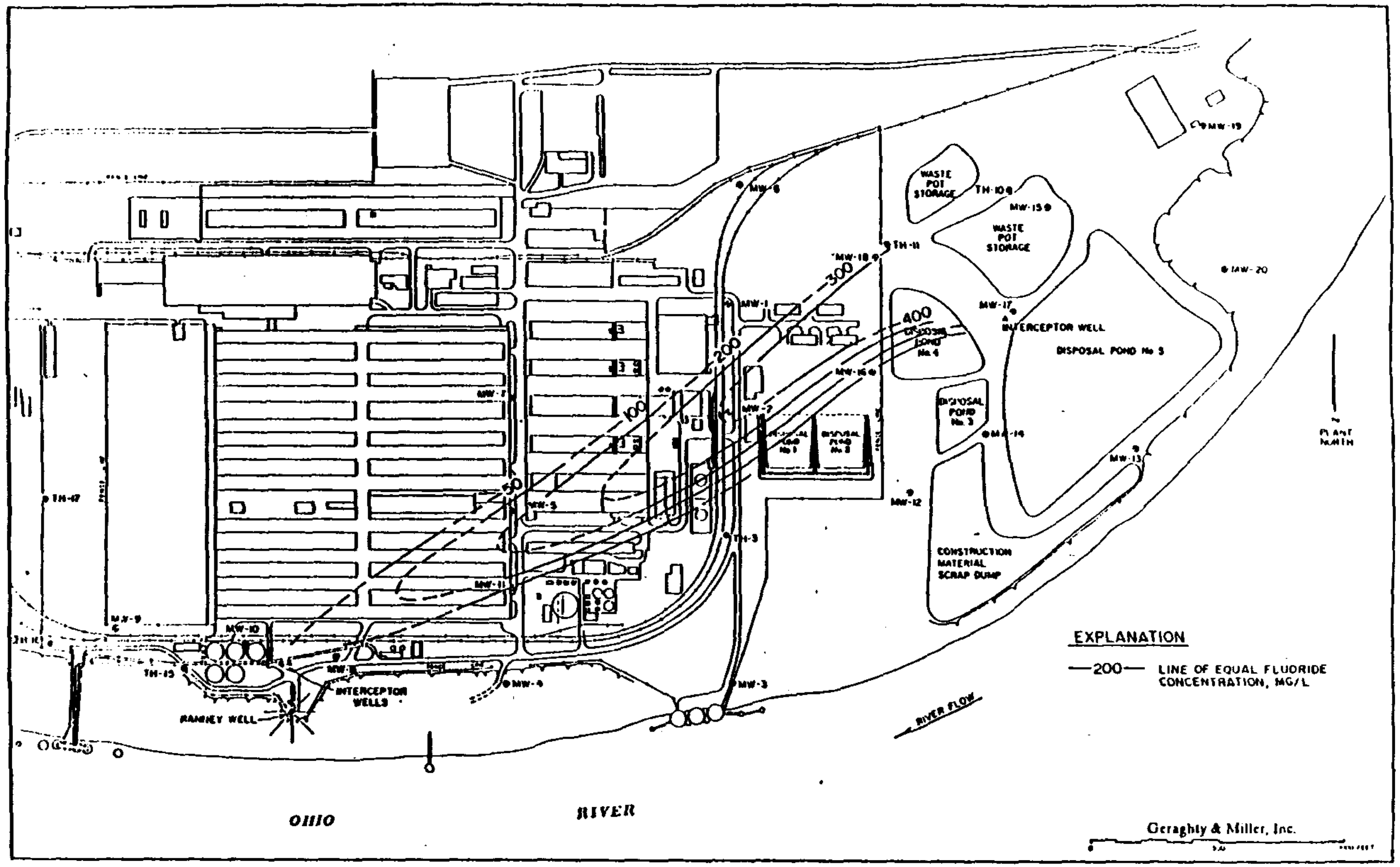


Figure 17. Fluoride Isopleth Map, Ormet Corporation, Hannibal, Ohio.
(Based on 02/84 water-quality data)

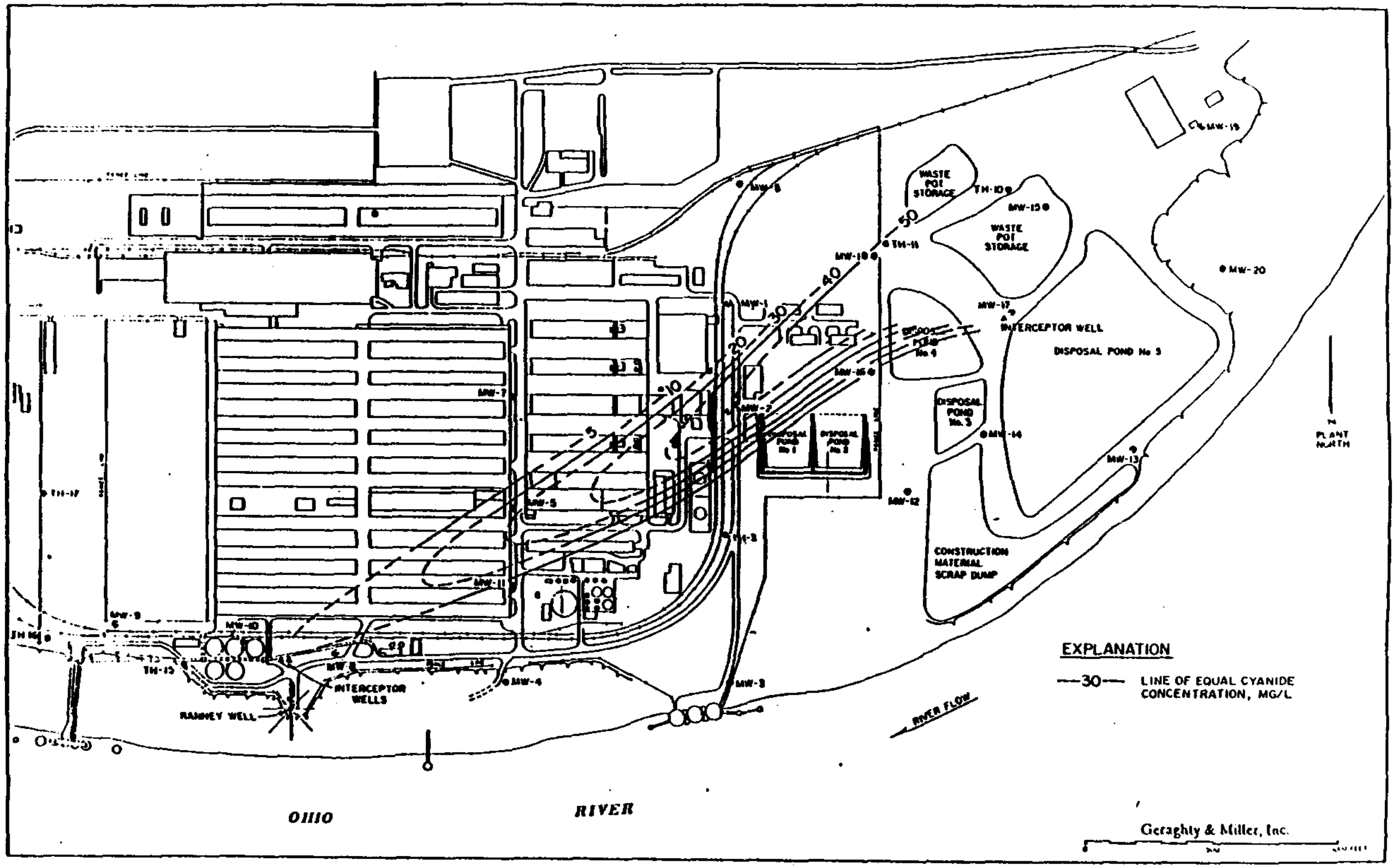


Figure 18. Cyanide Isopleth Map, Ormet Corporation, Hannibal, Ohio.
(Based on 02/84 water-quality data)

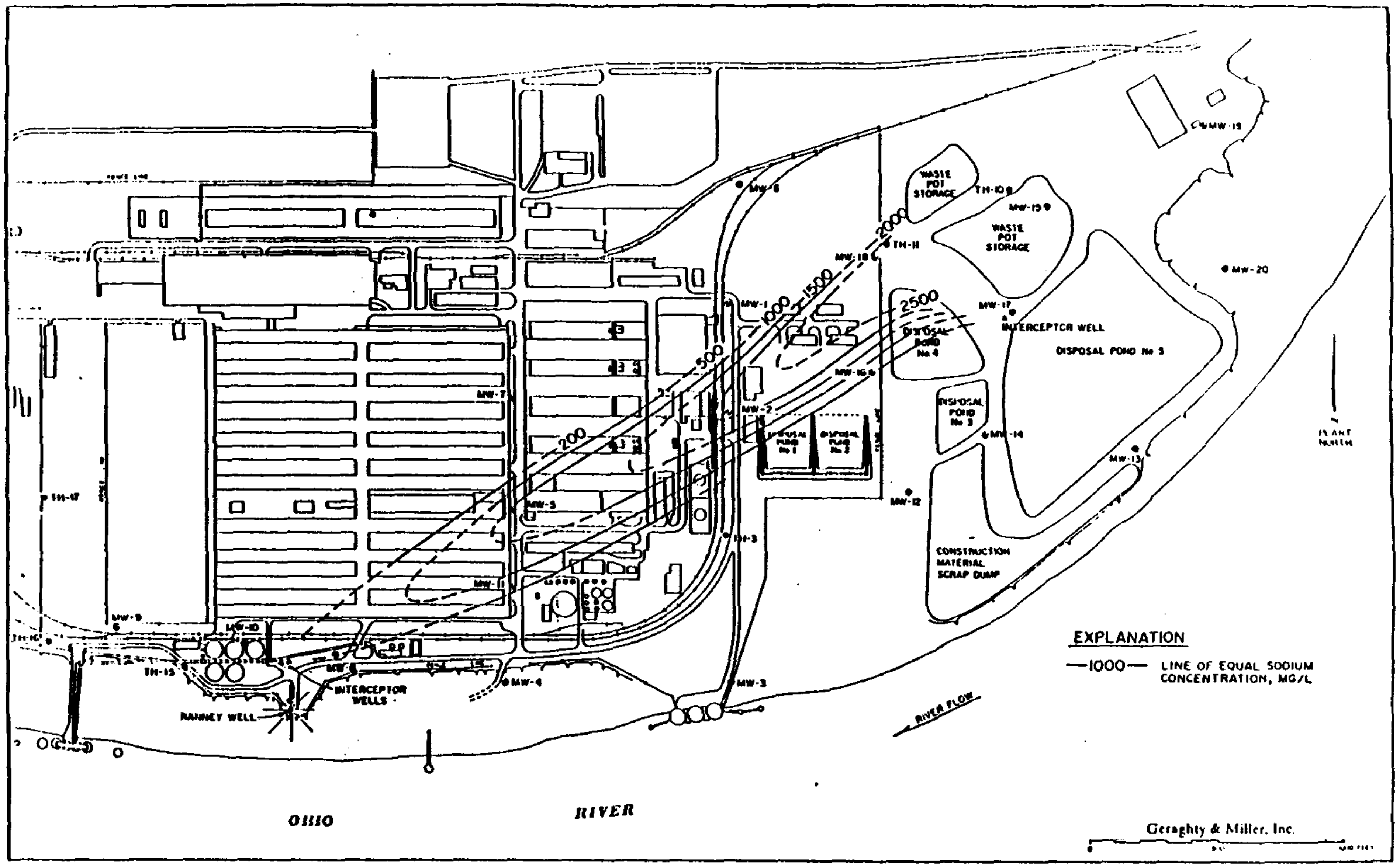


Figure 19. Sodium Isopleth Map, Ormet Corporation, Hannibal, Ohio. (Based on 02/84 water-quality data)

generation. If this is the case, a relatively concentrated slug of leachate may be moving outward from the former storage area.

It is interesting to note that Plume "A" effluents exhibit a strong positive correlation between total cyanide and total iron concentrations; i.e., high cyanide corresponds to high iron (see Figure 20). Because iron is relatively insoluble under high pH conditions characteristic of concentrated leachate plumes, this trend is believed to reflect the presence of iron-cyanide complexes within plume fluids.

Water-quality trends within Plume Section "B" are probably largely a result of effluent seepage from abandoned disposal ponds (especially pond No. 5), but may also be influenced by contaminant residues, remnant from past conditions, that have not yet been flushed from the aquifer system; flushing mediums include induced river recharge and infiltrating precipitation. In general, (although not consistently) wells situated within this plume show slightly elevated pH (up to pH 8), low to moderate fluoride levels (<1 to 5 mg/l), and low concentrations of total cyanide (<0.5 mg/l). Higher-than-background levels of sodium also seem to characterize Plume "B", but this trend is less consistent.

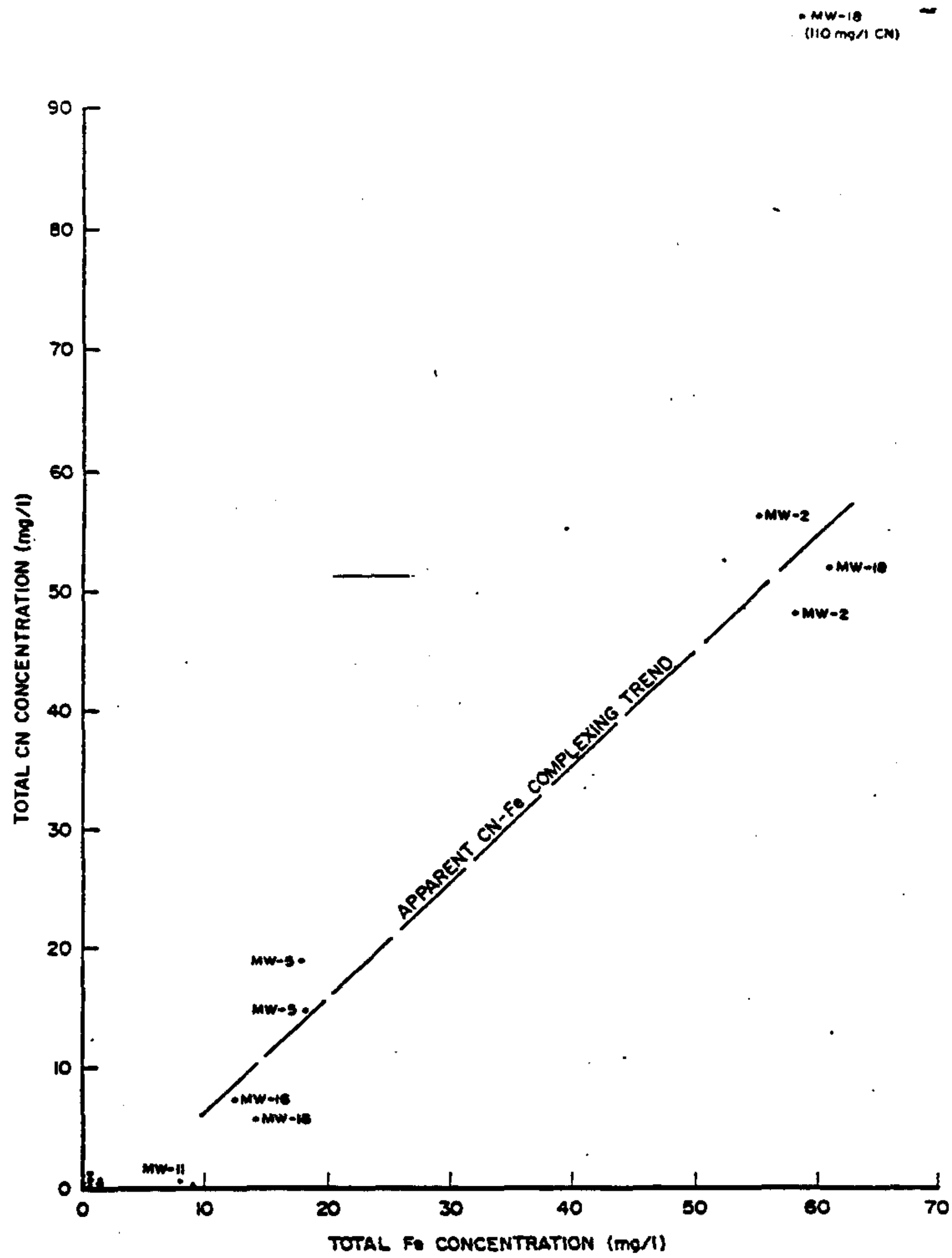


Figure 20. Total Cyanide Versus Total Iron Concentration Trends, Ormet Corporation, Hannibal, Ohio.

Plume Section "C", as stated earlier, is thought to result from intermittent shifts in groundwater flow conditions. Boundaries indicated for this plume are very speculative, and water-quality trends are probably less consistent than those characterizing plumes A and B. In general, Plume "C" is characterized by relatively low-level concentrations of common leachate indicator parameters (i.e., pH, F, CN, and Na). Other plume conditions, such as elevated temperature and relatively high conductivity and TDS values at MW-10 (i.e., high for the pH observed at this well), suggest that Plume "C" may also receive fluids emanating from other sources, such as leaking storm sewers or steam-venting facilities.

SOURCE-RELATED EFFECTS ON GROUNDWATER

Sludge Disposal Area

Water-quality impacts resulting from sludge disposal practices appear to have been partially abated by neutralizing sludge prior to discharge (1976), and probably became further reduced as a result of discontinued sludge disposal in 1981. Under present conditions (based on 1983-1984 data), the quality of groundwater moving beneath the No. 5 disposal pond appears suitable for many processing uses. In particular, the pH has dropped to a near-neutral range, and potential problems related to incrustation by silicate and organic carbon precipitates are probably much less apt to occur as a result of No. 5 disposal pond effluents.

It is possible (perhaps probable) that the quality of groundwater affected by disposal ponds will continue to improve with time, barring major changes or disturbances in sludge bed conditions. However, affected groundwater probably will not be suitable as a source for drinking water supplies in the near future.

Former Potliner Storage Area

Under present conditions, the quality of groundwater apparently emanating from beneath former potliner storage areas is unacceptable for drinking water supplies and is also potentially damaging to pumping wells and processing equipment. The latter problems relate mainly to increased incrustation on well screens and within gravel packs, and increased scaling on heat exchange equipment. These conditions are believed to be related to elevated concentrations of silica and/or total organic carbon (and possibly other constituents such as aluminum) within high-pH plume fluids.

As can be seen on Figures 13 and 14, there is a positive correlation between high pH and elevated concentrations of silica and TOC. Increased incrustation (precipitation) is believed to result from decreases in pH (and consequent reductions in SiO_2 and TOC solubility) that occur at pumping centers when high-pH plume fluids mix with groundwater having a near-neutral pH. Increased scaling on heat exchange equipment probably occurs for similar reasons, as well as possible solubility reductions upon increasing the temperature of the fluid. In either case, the end result could be super-saturation of dissolved and/or colloidal constituents, which causes precipitation and/or aggregation.

As can be seen on Figure 13, SiO_2 versus pH data for several wells (e.g., MW-18 and MW-2) plot within an area of the silica solubility range where fairly minor reductions in pH would result in super-saturation of dissolved silica; i.e., points would be shifted to the left of the calculated solubility curve for amorphous silica (Curve A), which probably represents the upper limit of saturation for dissolved silica. Solubility data for organic carbon species are less precise, but it is believed that similar trends may also apply.

Future Considerations

At the present time, pumping of Ormet's Ranney and old interceptor wells appears to be preventing migration of degraded groundwater beyond the plant boundaries. However, if yields from these wells continue to decrease over time, or if pumping were to be interupted or discontinued, off-site migration of leachate plumes would be likely to occur. Therefore, in order to maintain control over leachate plume migration using the existing system of wells, it is necessary that pumping be continued at or near current rates.

ALTERNATIVE REMEDIAL MEASURES

General

The previous section listed some existing and potential effects that have, or may, occur as a result of effluent discharges from disposal ponds and potliner storage areas. For the most part, these effects relate to limitations to which groundwater resources beneath the Ormet site can be utilized, with respect to both process-water and sanitary-water supplies. In addition, a potential also exists for migration of leachate plumes beyond Ormet's site boundaries. Consequently, considerations of possible remedial measures to abate potential and existing groundwater impacts should focus on two basic objectives: 1) controlling migration of leachate plumes within the aquifer system and 2) improving aquifer conditions beneath the Ormet plant site. Possible means by which these objectives could be accomplished are discussed in the following sections.

Controlling Leachate Plume Migration

Under present conditions, pumping of Ranney and interceptor wells within Buck Hill Bottom has created two large cones of influence which converge to form a gently rounded crest, or drainage divide, that appears to be situated roughly parallel to Ormet's west property boundary (see Figure 12). This divide acts as a hydraulic barrier to lateral groundwater flow and is essential in preventing westward migration of leachate plumes. Consequently, in order to control plume migration to the west, it is necessary that the drainage divide be maintained at or near its current position. This may become increasingly more difficult if incrustation at Ormet's Ranney and old interceptor wells continues to decrease pumpage; i.e., as pumpage at the Ormet wells decreases, the resultant cone of influence, and the ability to control plume migration, will also decrease.

Owing to this potential, it is recommended that Ormet monitor water-level and water-quality conditions beneath western plant areas so as to provide early warning of any changes in the position of the drainage divide. If monitoring results begin to indicate that the divide is shifting ~~eastward~~ west, it may be in Ormet's best interest to establish additional facilities that could be used to maintain (or perhaps even increase) the integrity of the drainage divide.

The most feasible alternatives for accomplishing this objective include removal and/or injection of water. Removal would basically involve installing additional pumping wells that could be operated to maintain necessary drawdowns beneath the Ormet site. These wells should be located in the vicinity of (perhaps north of) the Ranney and old interceptor wells so as to compound the drawdown effects (i.e., overlap cones of influence) from existing and new pumping facilities. The volume of groundwater that would have to be produced (and the number of wells needed) probably depends largely on the extent of decrease in Ranney and old interceptor well production. A potential disadvantage of the pumping well alternative is that the saturated thickness of the aquifer beneath this area of the plant ranges from only 20 to 30 feet, which limits the yield that can be obtained from a single well. This could necessitate the installation of a greater number of wells (at a greater expense) in order to create the drawdowns needed to control plume migrations. Also, it is likely that, over time, new pumping wells may also experience incrustation problems and may have to be serviced on a fairly regular basis.

The second alternative of injecting water into the aquifer would involve installing several wells (probably at least three) in a line roughly parallel to the existing drainage divide. These wells could then be used to inject the volumes of water needed to maintain a hydraulically high zone beneath Ormet's west plant boundary. Unlike pumping facilities, the injection wells would not be susceptible to problems relating to incrustation and/or limited aquifer thickness. However, for the injection systems to operate efficiently over the long term, it is necessary that injected water be virtually free of suspended sediments, which would eventually clog the well screen and adjacent aquifer deposits. If clean groundwater were used, suspended sediments probably would not pose a problem. However, if river water represents the only feasible source, treatment would have to be performed, and the resultant increase in costs could become a discouraging factor. In addition, it may be necessary to obtain injection well permits in order to legally operate this type of system.

It should be noted that other physical-type barriers, such as slurry walls and sheet pilings, can also be used to block plume migrations. However, depths to bedrock (±100 feet) and the presence of buried cables and pipes beneath this area of the Ormet plant diminish the technical and economic feasibility of implementing these types of control systems.

Improving Ormet's Groundwater Conditions

Alternatives for accelerating the improvement of aquifer conditions basically fall into one of two categories, namely: aquifer management and source-area management. In general, aquifer management strategies focus on alleviating or controlling adverse conditions that already exist within the groundwater system, whereas, source-area management practices are aimed more at reducing or preventing further degradation of the system. Some of the more common methods that can be used in these management programs are listed in Table 2.

A reasonable initial goal for improving aquifer conditions beneath the Ormet plant site would be to restore groundwater quality to a level acceptable for processing uses. Under present conditions, it appears that groundwater moving beneath the No. 5 disposal pond (and probably other disposal ponds) may already be approaching this level of quality; and it is possible (perhaps probable) that, over time, the quality of groundwater beneath this area will become more improved as soluble and/or reactive sludge components become depleted. It is, therefore, probably in Ormet's best interest to continue groundwater monitoring at selected locations around the disposal ponds,

TABLE 2.
COMMON ALTERNATIVES FOR ACCELERATING IMPROVEMENT
OF AQUIFER CONDITIONS

Aquifer Management Alternatives	Source-Area Management Alternatives
. Removal of contaminants via pumping wells, collection drains, or ditches	. Removal of contaminant source materials via excavation or pumping
. Containment of con-aminants via physical and/or hydraulic barriers	. Reduction of leachate generation via grading or capping
. In-situ stabilization (neutralization) of contaminants via chemical and/or biological treatment	. Encapsulation of source materials and effluents via physical barriers
	. Stablization of source materials via chemical and/or biological treatment

because long-term water quality trends (collected over at least a one-year period) could indicate stable or improving conditions that may not warrant implementation of high-cost remedial actions.

Groundwater that appears to be moving beneath former potliner storage areas exhibits water-quality conditions that can promote incrustation of pumps and well screens, and increased scaling within pipes and heat exchange equipment. Consequently, accelerating improvement of potliner-related groundwater conditions may be desirable, in that, it could help to reduce Ormet's dependency on outside water sources; and may also help to increase the reliability of pumping-type remedial measures that may be used to maintain hydraulic barriers beneath western plant areas.

A first step toward accomplishing this objective would be to complete the removal of any remaining piles or accumulations of potliner material, and establish a grade that prevents pooling of surface water in former potliner storage areas. The next logical step would be to continue groundwater monitoring(for at least a year or more) at selected locations to assess the effectiveness of source-area management efforts. If water-quality trends indicate that conditions are beginning to show a progressive improvement, it may only be necessary to restore vegetation to this area in order to prevent erosion. If water-quality trends show no change or indicate worsening conditions, it may be necessary to consider additional remedial measures for reducing leachate generation.

Ormet is currently implementing an aquifer management alternative, in that, pumping of their Ranney and interceptor wells serves to remove leachate plumes already present within the aquifer system, and controls migration of these plumes beyond Ormet's property boundaries. In the event that a more intensive aquifer management is needed, such as additional wells to control plume movements beneath western plant areas, a further investigation of aquifer hyudraulic properties is suggested in order to determine the most effective methodologies for accomplishing the established aquifer management objectives.

CLOSING COMMENTS

Data derived through the recent and past investigations conducted at the Ormet site provide a good base for explaining existing hydrogeologic conditions, and will be useful in interpreting the cause(s) and significance of water-quality changes that may occur in the future. Of particular importance, findings from the recent study suggest that:

- Impacts to Ormet's process-water supplies are mostly pH-related
- Adverse water-quality effects from sludge disposal ponds have declined in recent time, and current groundwater alterations may be largely related to former potliner storage areas
- Plumes of degraded groundwater appear to be contained within Ormet's site boundaries as a result of pumping from Ranney and interceptor wells
- Disturbances to storage and/or disposal areas (e.g. grading or excavation) could cause short-term increases in the rates of leachate generation
- Potliner-related and sludge disposal-related effects on groundwater quality can be distinguished based on groundwater flow patterns and water temperature trends
- Existing and potential groundwater quality impairment can probably be abated through a combination of source-area management and aquifer-management practices.

Through continued groundwater monitoring, it is anticipated that the accuracy and overall significance of these findings will become better defined. Continued collection of water-level and water-quality data should also provide for a more comprehensive understanding of conditions occurring within the water-table aquifer. This is an important requirement for selecting and implementing effective remedial measures to achieve established groundwater management objectives.

Respectfully submitted,

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APPENDIX A

LITHOLOGIC DESCRIPTIONS AND MONITOR WELL CONSTRUCTION DETAILS FROM THE DECEMBER 1983 DRILLING/WELL INSTALLATION PROGRAM AT THE ORMET CORPORATION PLANT SITE HANNIBAL, OHIO

Note: Material referred to as rock fragments probably mainly represents broken or weathered pebbles

WELL MW-1
(installed 11/28/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Pebbles, sand, and silt, black to dark brown color; probably represents fill
5.0 - 6.5	7-6-5	Pebbles, sand, silt, and clay, dark brown color; probably represents fill
10.0 - 11.5	5-6-6	Pebbles, rock fragments, sand, and silt, brown color
15.0 - 16.5	10-12-15	Pebbles and medium sand, minor black (peat type) material, grey to green color; probably natural
20.0 - 21.5	5-6-15	Sand, medium, with minor rock fragments, grey to green color
25.0 - 26.5	10-23-32	Sand, medium, with pebbles, rock fragments, and several thin layers of black (peat type) material, grey to green color
30.0 - 31.5	7-11-12	Sand, medium, with black (peat type) layers, and pebbles, grey to green color
35.0 - 36.5	6-12-17	Sand, medium, with some pebbles, grey to green color
40.0 - 41.5	8-10-12	Sand, medium, with some pebbles, grey to green color
45.0 - 46.5	7-8-13	Sand, fine to medium, with pebbles and minor amounts of silt, grey to green color

WELL MW-1 (Cont)
(installed 11/28/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	10-13-15	Sand, medium, with pebbles, brown to tan color
55.0 - 56.5	10-13-11	Sand, medium to coarse, with pebbles and silt, rust brown color; hit water at about 54.5 feet
60.0 - 61.5	8-6-8	Sand, medium to coarse, with pebbles and silt, rust brown color
65.0 - 66.0	dropped rods-26	Sand, fine to medium, with some pebbles, rust brown color
66.0 - 69.0	-	Bedrock at about 67 feet; auger refusal at about 69 feet; bedrock appears to consist mostly of grey shale and/or mudstone

Borehole depth: 69 feet
Well depth: 69 feet
Screened interval: 69 to 49 feet
Well construction: 49 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch slot PVC screen; about 2 feet of PVC stick up
Comments: Cave-in to about 45 feet; sand pack to about 35 feet; 0.5 feet of bentonite on top of sand; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-2
(installed 11/29/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Cinder-type material, sand, and a few rock fragments, black color; probably represents fill
5.0 - 6.5	-	No sample attempted to avoid potential damage to buried pipes
10.0 - 11.5	5-3-3	No recovery
15.0 - 16.5	8-10-16	Rock fragments, sand, and silt, brown to green color; maybe natural
20.0 - 21.5	5-5-8	Sand, fine to medium, with pebbles and several thin layers of dark (peat type) material, brown color; hit perched water at about 20 feet
25.0 - 26.5	6-7-8	Pebbles, rock fragments, sand, and silt, brown to green color
30.0 - 31.5	9-50/1"	Rock fragments, pebbles, sand, and minor silt and dark (peat type) material, brown to tan color
35.0 - 36.5	6-5-13	Rock fragments, pebbles, sand, and minor silt and dark (peat type) material, brown color
40.0 - 41.5	7-9-10	Sand, medium, and pebbles, with minor rock fragments, brown color
45.0 - 46.5	11-21-29	Sand, medium, and pebbles and rock fragments, with minor dark (coal type) material, brown to green color

WELL MW-2 (Cont)
(installed 11/29/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	28-29-27	Sand, medium, and rock fragments and pebbles, brown to tan color
55.0 - 56.5	22-24-27	Sand, medium, and pebbles, brown to tan color
60.0 - 61.5	15-27-21	Pebbles, medium to coarse sand, and some rock fragments, brown color; hit water at about 57.5 feet
65.0 - 66.5	-	Sand, medium to coarse, and small pebbles, brown color; sample taken from auger run-up
70.0 - 71.5	21-27-26	Sand, medium to coarse, with small pebbles, brown color
75.0 - 76.5	26-17-20	Sand, medium to coarse, and small pebbles, with minor silt, brown color
80.0 - 81.5	26-28-17	Sand, medium to coarse, changing to predominantly rock fragments at base of sample, brown color
85.0 - 86.0	16-51/3"	No recovery; split spoon broke off and was left in bottom of hole
86.0	-	Bedrock and auger refusal at about 86 feet

Borehole depth: 86 feet
Well depth: 84 feet
Sceened interval: 84 to 54 feet
Well construction: 54 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 48 feet; sand pack to about 39 feet; 0.5 feet of bentonite on top of sand; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-3
(installed 11/29/83 to 11/30/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Pebbles, sand, and silt, brown color; probably represents fill
5.0 - 6.5	3-5-6	Clay with silt, minor sand, and a few pebbles, brown to dark brown color; probably natural
10.0 - 11.5	1-2-5	Clay with silt, minor sand, and a few small pieces of cinder-type material, brown color; probably natural
15.0 - 16.5	2-3-6	Clay with silt, mottled brown to rust brown color
20.0 - 21.5	2-3-2	Clay with silt, soft and plastic, brown color
25.0 - 26.5	3-3-6	Clay with silt, very soft and plastic, brown color
30.0 - 31.5	WOR-1	Silt with clay, minor amounts of very fine sand, very soft and plastic, brown color; probably hit water at about 31 feet
35.0 - 36.5	WOR-WOH-1	Silt and very fine sand, with minor clay, very soft, brown color
40.0 - 41.5	WOR-3-4	Silt and very fine sand, with minor clay, very soft, brown color
45.0 - 46.5	WOR-2-4	Silt and very fine sand, oozy soft, brown color

WELL MW-3 (Cont)
(installed 11/29/83 to 11/30/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	14-21-14	Pebbles and medium to coarse sand, brown color
55.0 - 56.5	18-17-18	Pebbles, fine to coarse sand, silt, and some rock fragments and clay, brown to grey color
60.0 - 61.5	7-7-7	Sand, coarse, and small pebbles, brown color
65.0 - 66.5	4-8-6	Sand, medium to coarse, and several layers (up to 2-inch-thick) of black (peat type) material, brown color
70.0 - 71.5	-	Sand, medium to coarse, brown color; sample taken from auger run-up
75.0 - 76.0	-	Sand, medium to coarse, and small to large pebbles; sample taken from auger run-up
76.0 - 77.0	-	Bedrock at about 76 feet; auger refusal at about 77 feet

Borehole depth: 77 feet
Well depth: 76.5 feet
Screened interval: 76.5 to 46.5
Well construction: 46.5 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 31 feet; sand pack to about 29 feet; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-4
(installed 11/30/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Silt, roots, and a few small rock fragments, soil texture, brown color; probably represents fill
5.0 - 6.5	2-1-2	Silt, fine sand, pebbles, and a few rock fragments, soil texture, brown color; may represent fill
10.0 - 11.5	3-3-5	Clay with some silt, mottled brown color; may represent fill
15.0 - 16.5	4-7-7	Sand, medium to fine, with rock fragments and some silt, brown color
20.0 - 21.5	5-3-6	Sand, fine to medium, with some silt and minor clay, and a few pebbles, brown color
25.0 - 26.5	5-6-5	Clay with silt, pebbles, and a few rock fragments, brown to dark brown color
30.0 - 31.5	10-13-16	Pebbles and silt with some clay and a few rock fragments, brown to dark brown color
35.0 - 36.5	6-8-11	Clay, with minor silt, fairly dense, dark brown to olive green color
40.0 - 41.5	4-7-8	Clay, with some silt, fairly dense, mottled tan to brown color
45.0 - 46.5	7-10-13	Clay, with minor silt, and hairline fractures filled with black (peat type) material, fairly dense, brown color
50.0 - 51.5	6-7-9	Silt, very fine sand, and clay, brown color

WELL MW-4 (Cont)
(installed 11/30/83)

Sample Depth Interval (ft)	Blow Count	Description
55.0 - 56.5	8-13-14	Silt, fine to medium sand, pebbles, and some clay and black (peat type) material, brown color
60.0 - 61.5	5-7-7	Pebbles, rock fragments, and silt, with minor clay, brown color; sample is damp
65.0 - 66.5	WOR	Sand, medium to coarse, pebbles and silt, brown color; hit water at about 62 feet
70.0 - 71.5	11-10-9	Sand, medium to coarse, and a few small pebbles, brown color
75.0 - 76.5	12-22-25	Sand, medium to coarse, and a few small pebbles, brown color
80.0 - 81.5	11-13-15	Sand, medium to coarse, brown color
85.0 - 86.5	37-24-19	Sand, medium to coarse, and a few small pebbles, brown color
90.0 - 91.5	14-11-12	No recovery, probably same as above
93.0 - 94.0	-	Bedrock at about 93 feet; auger refusal at about 94 feet

WELL MW-4 (Cont)
(installed 11/30/83)

Borehole depth: 94 feet
Well depth: 74 feet
Screened interval: 74 to 54 feet
Well construction: 54 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Bottom 20 feet of augers broke off and were left in borehole beneath the monitor well; cave-in to about 61 feet; sand pack to about 44 feet; 0.5 feet of bentonite on top of sand; formation cuttings up to about 5 feet; cement up to ground level; protective cover installed

WELL MW-5
(installed 12/01/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Black top (about 4 inches thick) changing to fill consisting of rock fragments, clay, silt, and some pebbles, dark brown to black color
5.0 - 6.5	grab	Pebbles, silt, and clay, brown color; probably represents fill
10.0 - 11.5	2-3-4	Rock fragments, pebbles, silt, sand, minor clay, and some cinder type material, brown color; probably represents fill; sample is wet
15.0 - 16.5	11-12-13	Pebbles, silt, rock fragments, and fine to medium sand, brown to tan color; probably mostly represents fill; hit perched water at about 11 feet
20.0 - 21.5	5-7-8	Sand, medium grained, with pebbles and silt, and a layer (about 1 inch thick) of black (peat type) material, brown color; sample is probably natural
25.0 - 26.5	3-6-8	Sand, medium, pebbles and silt, with some black (peat type) material, brown color
30.0 - 31.5	5-8-11	Sand, medium, with some pebbles and silt, and a few rock fragments, brown color
35.0 - 36.5	9-9-9	Sand, medium, with pebbles, some silt, and minor black (peat type) material, brown color; sample is damp
40.0 - 41.5	4-5-8	Sand, medium to coarse, with some pebbles and rock fragments, and minor silt, brown color; sample is damp

WELL MW-5 (Cont)
(installed 12/01/83)

Sample Depth Interval (ft)	Blow Count	Description
45.0 - 46.5	7-9-19	Sand, fine to coarse, pebbles, and some silt, brown color; sample is damp
50.0 - 51.5	6-7-9	Sand, medium to coarse, with pebbles and some rock fragments, brown color; sample is damp
55.0 - 56.5	20-25-23	Sand, coarse, with rock fragments, pebbles, and minor silt, brown color; hit perched water at about 54 feet
60.0 - 61.5	10-16-19	Sand, coarse, with some small pebbles and minor silt, brown color; sample is damp
65.0 - 66.5	20-24-25	Sand, medium to coarse, with some pebbles, brown color; sample is damp
70.0 - 71.5	15-21-25	Sand, medium to coarse, and pebbles, brown color; <u>hit water at about 67 feet</u>
75.0 - 76.5	10-12-14	Sand, medium , with some small pebbles, brown color
80.0 - 81.5	drop-16-42	Sand, medium to coarse, and some pebbles, brown color
85.0 - 86.5	8-10-11	Sand, medium to coarse, and some pebbles, brown color
91.0 - 93.0	35-20-16-16	Sand, medium to coarse, changing to rock fragments and silty to sandy clay at bottom of sample, brown color
93.0 - 95.0	-	No sample, drove rods until refusal; bedrock at about 95 feet

WELL MW-5 (Cont)
(installed 12/01/83)

Borehole depth: 90 feet
Well depth: 90 feet
Screened interval: 90 to 60 feet
Well construction: 60 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 21 feet; sand pack to about 19 feet; 0.5 feet of bentonite on top of sand; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-6
(installed 12/01/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Sand, medium, and silt with some small pebbles, brown color; probably represents fill
5.0 - 6.5	5-3-3	Sand, clay, silt, and some pebbles, brown color, probably represents fill
10.0 - 11.5	3-2-3	Sand, medium to fine, with some silt and rock fragments, brown color; material is probably natural
15.0 - 16.5	4-7-8	Sand, fine to medium, and a few small pebbles, brown color; only about a 3-inch recovery
20.0 - 21.5	3-5-4	Sand, medium to fine, with some black (peat type) material, brown color; lower part of sample is damp
25.0 - 26.0	3-4-5	Sand, fine to medium, with a few pebbles, brown color; hit perched water at about 22 feet
30.0 - 31.5	3-2-2	Sand, medium to fine, with a few pebbles, changing to silty clay, brown color; change at about 31 feet
35.0 - 36.5	WOH	Clay, silty to sandy, brown to orange color, changing to sand, fine grained, with a few pebbles, grey to green color; change at about 36 feet
40.0 - 41.5	2-10-9	Sand, fine to medium, with silt and clay, some black (peat type) material, and some small rock fragments, dark grey to green color

WELL MW-6 (Cont)
(installed 12/01/83)

Sample Depth Interval (ft)	Blow Count	Description
45.0 - 46.5	19-26-47	Clay, very hard and stiff, green to dark grey color; sample is very dry
50.0 - 51.5	50/4"	Coal, black color, changing to very stiff, hard clay, grey color
51.0 - 52.5	-	Bedrock at about 51 feet; auger refusal at about 52.5 feet

Borehole depth: 52.5 feet
Comments: No well was installed because of suspected limited extent of the water table aquifer in this area, i.e., it is believed that mostly perched water was encountered; hole was back-filled with cuttings and marked by flat rock.

WELL MW-7
(installed 12/02/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Blacktop (about 4-inches thick) changing to fill consisting of sand, silt, and pebbles, brown color
5.0 - 6.5	2-3-5	Sand, medium to fine, silt, rock fragments, and pebbles, brown color; probably represents fill
10.0 - 11.5	7-7-7	Sand, medium to coarse, silt, rock fragments, and pebbles, brown color
15.0 - 16.5	6-9-9	Sand, fine to medium, and a few pebbles, brown color; sample is probably natural
20.0 - 21.5	14-21-20	Sand, medium to fine, with some pebbles and rock fragments, brown color; augers were bringing up water, possibly storm drain leakage
25.0 - 26.5	11-15-26	Sand, medium to fine, with some pebbles and a few rock fragments, brown color
30.0 - 31.5	12-20-23	Sand, medium to fine, with some pebbles, brown color
35.0 - 36.5	9-11-13	Sand, medium to fine, with some pebbles, a few rock fragments, and a layer (about 2 inches thick) of black (peat type) material, brown color
40.0 - 41.5	18-16-20	Sand, fine to medium, with some pebbles and a few rock fragments, brown color
45.0 - 46.5	21-19-22	Sand, medium, with some pebbles and rock fragments, and minor silt, brown color

WELL MW-7 (Cont)
(installed 12/02/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	18-11-11	Sand, medium, with pebbles and a few rock fragments, brown color
55.0 - 56.5	9-10-11	Sand, fine to medium, with some pebbles, brown color
60.0 - 61.5	13-7-10	Sand, medium to coarse, with pebbles and some silt, brown color, changing to clay and silt, with pebbles and some sand, rust brown color; change at about 61 feet; sample is damp
65.0 - 66.5	11-7-8	Clay and silt, with sand and some pebbles and rock fragments, brown to rust brown color; hit water at about 64 feet
70.0 - 71.5	14-13-14	Pebbles, sand, and silt, brown to green color
75.0 - 76.5	67/6"	Sand, silt, and rock fragments, changing to decomposed rock, brown color
77.0 - 79.0	-	Bedrock at about 77 feet; auger refusal at about 79 feet

Borehole depth: 79 feet
Well depth: 78 feet
Screened interval: 78 to 58 feet
Well construction: 58 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 21 feet; 1 foot of bentonite on top of cave-in; formation cuttings up to about 5 feet; cement up to ground level; protective cover installed

WELL MW-8
(installed 12/02/83 and 12/04/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Sand, silt, and some small pebbles, brown color; probably represents fill
5.0 - 6.5	3-2-2	Silt and sand, with some clay and a few pebbles, brown color; probably represents fill; sample is damp
10.0 - 11.5	2-2-2	Clay with silt, some sand, and a few pebbles, brown to rust brown color, sample is probably mostly natural; sample is damp
15.0 - 16.5	3-4-5	Clay with minor silt, fairly dense, brown to rust brown color
20.0 - 21.5	5-8-9	Clay with some silt, minor sand, and a few pebbles, brown color
25.0 - 26.5	7-8-11	Clay with minor silt, brown to rust brown color
30.0 - 31.5	6-11-23	Clay with some silt and minor fine sand, fairly dense and plastic, mottled brown to green color, changing to silt with some clay and a few pebbles, fairly hard and stiff, grey color; change at about 31.5 feet
35.0 - 36.5	6-7-7	Sand, fine to very fine, with minor silt, brown to tan color
40.0 - 41.5	7-8-8	Sand, fine to very fine, brown to tan color
45.0 - 46.5	6-7-9	Sand, fine to very fine, brown to tan color

WELL MW-8 (Cont)
(installed 12/02/83 and 12/04/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 56.5	9-10-7	Sand, medium to coarse, with pebbles, a few rock fragments, and pebbles, brown to tan color
55.0 - 56.5	4-8-10	Sand, medium to coarse, with pebbles, a few rock fragments, and minor black (peat type) material, brown color
60.0 - 61.5	6-6-10	Sand, fine to medium, with some pebbles, brown color
65.0 - 66.5	13-13-16	Sand, medium to coarse, with pebbles, brown color
70.0 - 71.5	12-14-15	Sand, medium, with some pebbles and a minor silty zone, brown color
75.0 - 76.5	7-9-11	Sand, medium to coarse, and some pebbles, brown color; hit water at about 75 feet
80.0 - 81.5	dropped	Sand, medium to coarse, with some pebbles, brown color
85.0 - 86.5	9-16-25	Sand, medium to coarse, and some pebbles, brown color
90.0 - 91.5	13-18-18	Sand, medium to coarse, and pebbles, brown color
95.0 - 96.5	11-14-20	Sand, medium to coarse, and a few pebbles, brown color
97.0 - 98.0	-	Bedrock and auger refusal at about 98 feet

WELL MW-8 (Cont)
(installed 12/02/83 and 12/04/83)

Borehole depth: 98 feet
Well depth: 98 feet
Screened interval: 98 to 68 feet
Well construction: 68 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 50 feet; sand pack to about 48 feet; 0.5 feet of bentonite on top of sand pack; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-9
(installed 12/05/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Clay, silt, and pebbles, brown color; probably represents fill
5.0 - 6.5	2-2-2	Clay, silt, pebbles, and some black (cinder type) material; probably represents fill
10.0 - 11.5	5-8-10	Clay, with silt and some fine sand, and a few rock fragments, fairly dense, brown color; probably natural
15.0 - 16.5	5-7-22	Clay with silt, becoming more pebbly and sandy towards base, fairly dense, brown color; probably natural
20.0 - 21.5	5-7-10	Clay with some silt, fairly dense, brown color
25.0 - 26.5	5-17-24	Pebbles and silt, with some clay and minor sand, dark brown color
30.0 - 31.5	7-7-10	Silt with clay, dark brown color
35.0 - 36.5	5-8-9	Silt and very fine sand, with minor clay, brown color
40.0 - 41.5	5-7-8	Sand, very fine, and silt, brown color
45.0 - 46.5	5-8-9	Sand, very fine, and some pebbles, brown color
50.0 - 51.5	5-8-9	Pebbles, with some sand and silt, brown color

WELL MW-9 (Cont)
(installed 12/05/83)

Sample Depth Interval (ft)	Blow Count	Description
55.0 - 56.5	5-6-8	Pebbles, with medium to coarse sand, and minor silt, brown color
60.0 - 61.5	10-11-15	Sand, fine to medium, with pebbles and a layer (about 1-inch thick) of black (peat type) material, brown color
65.0 - 66.5	18-19-18	Sand, medium to coarse, and pebbles, brown color
70.0 - 71.5	8-8-9	Sand, medium to coarse, and pebbles, brown color; hit water at about 70 feet
75.0 - 76.5	15-18-20	Sand, medium to coarse, and pebbles, brown color
80.0 - 81.5	14-15-19	Sand, medium to coarse, and some small pebbles, brown color
85.0 - 86.5	18-16-16	Sand, medium to coarse, and some pebbles, brown color
90.0 - 91.5	9-10-11	Sand, medium to coarse, and pebbles, brown color
95.0 - 96.5	10-11-16	Sand, medium to coarse, and a few pebbles, brown color
100.0 - 100.5	51/6"	Sand, medium to coarse, with some small pebbles, brown color, changing to clay with sand, pebbles, and rock fragments, grey to brown color
100.5 - 101.0	-	Bedrock and auger refusal at about 101 feet

WELL MW-9 (Cont)
(installed 12/05/83)

Borehole depth: 101 feet
Well depth: 101 feet
Screened interval: 101 to 71 feet
Well construction: 71 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 55 feet; sand pack to about 53 feet; formation cuttings to about 15 feet; 1 foot of cement and 0.5 feet of bentonite on top of cuttings; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-10
(installed 12/05/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Silt, sand, some clay and pebbles, and some alumina powder, brown to grey color; probably represents fill
5.0 - 6.5	6-6-6	Sand, fine, and silt, with a few pebbles and minor clay, brown color; probably represents fill
10.0 - 11.5	WOH	No recovery; based on blow count must be fairly oozy; probably represents fill; hit perched water at about 10 feet
15.0 - 16.5	19-17-21	Pebbles, rock fragments, silt, and some sand, dark brown color; probably represents compacted fill; driller through the lithology change occurred at about 13 feet
20.0 - 21.5	27-39-32	Poor recovery of only gravel; may be the same as above
25.0 - 26.5	10-8-5	Sand, medium, and silt with some pebbles, brown color; probably natural
30.0 - 31.5	7-14-19	Sand, fine, with some silt, brown color
35.0 - 36.5	7-9-12	Silt with fine sand, brown color
40.0 - 41.5	9-9-10	Sand, fine, with silt, brown color
45.0 - 46.5	9-10-12	Sand, fine, with minor silt and pebbles, brown color

WELL MW-10 (Cont)
(installed 12/05/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	7-9-10	Sand, fine, with some silt and pebbles, brown color
55.0 - 56.5	12-18-17	Sand, medium to coarse, with pebbles and minor silt, brown color
60.0 - 61.5	9-10-10	Sand, medium to coarse, with pebbles, minor silt, and some black (peat type) material, brown color
65.0 - 66.5	9-11-17	Sand, medium to coarse, with some pebbles, brown color
70.0 - 71.5	14-21-24	Sand, medium to coarse, and pebbles, with some rock fragments, brown color
75.0 - 76.5	13-11-10	Sand, medium, brown color; hit water at about 74 feet
80.0 - 81.5	15-16-21	Sand, medium to coarse, and some pebbles, with minor silt, brown color
85.0 - 86.5	9-19-24	Sand, medium to coarse, with some pebbles, brown color
90.0 - 91.5	14-18-23	Sand, coarse, with pebbles, brown color
95.0 - 96.5	17-30-28	Sand, medium to coarse, and pebbles, brown color
100.0-100.5	51/3"	Bedrock at about 100 feet; auger refusal at about 100.5 feet; decomposed rock on lead auger is grey color and looks like weathered shale or mudstone

WELL MW-10 (Cont)
(installed 12/05/83)

Borehole depth: 100 feet
Well depth: 100 feet
Screened interval: 100 to 70 feet
Well construction: 70 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 31 feet; sand pack and more cave-in to about 10 feet; 1 pack of cement plus more cave-in to about 5 feet; cement up to ground level; protective cover installed

WELL MW-11
(installed 12/06/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Blacktop (about 4-inches thick) changing to pebbles, silt, and sand, brown color; probably represents fill
5.0 - 6.5	-	No sample attempted because of buried pipes
10.0 - 11.5	3-3-4	Pebbles, silt, sand, and some clay, brown color; probably represents fill
15.0 - 16.5	9-12-18	Sand, medium, and silt, with some pebbles and rock fragments, brown color; probably natural; sample is damp
20.0 - 21.5	4-5-6	Silt with very fine sand, brown color
25.0 - 26.5	3-5-4	Silt with some very fine sand, changing to pebbles with medium to coarse sand, and minor silt, brown color
30.0 - 31.5	6-9-8	Sand, medium to coarse, with pebbles, rock fragments, and some silt, brown color
35.0 - 36.5	6-8-9	Sand, medium, with some pebbles and a few rock fragments, brown color
40.0 - 41.5	3-5-6	Sand, coarse, and pebbles, with some silt, brown color
45.0 - 46.5	4-6-5	Sand, coarse, with pebbles and some silt, brown color

WELL MW-11 (Cont)
(installed 12/06/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	9-11-10	Sand, medium to coarse, with some pebbles, a few rock fragments, and minor silt, brown color
55.0 - 56.5	22-22-25	Sand, medium to coarse, and pebbles, brown color
60.0 - 61.5	15-12-14	Sand, medium to coarse, with some pebbles and a layer (about 1/2-inch thick) of black (peat type) material, brown color
65.0 - 66.5	15-15-19	Sand, medium to coarse, with pebbles and a few rock fragments, brown color
70.0 - 71.5	17-26-27	Sand, medium, with a few pebbles, brown color
75.0 - 76.5	8-9-11	Sand, medium to coarse, and small pebbles, brown color; hit water at about 72 feet
80.0 - 81.5	8-11-16	Sand, medium to coarse, with some pebbles, brown color
85.0 - 86.5	52/4"	Rock fragments, dark grey color; driller thought he may have augered through cobbles from about 85 to 87 feet
90.0 - 91.5	7-8-9	Sand, medium to coarse, with a few small pebbles, brown color
95.0 - 95.5	65/3"	Bedrock and auger refusal at about 95.5 feet; no recovery on sample attempt

WELL MW-11 (Cont)
(installed 12/06/83)

Borehole depth: 95.5 feet
Well depth: 95.5 feet
Screened interval: 95.5 to 65.5 feet
Well construction: 65.5 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 1.5 feet of PVC stick-up
Comments: Cave-in to about 25 feet; sand pack to about 23 feet; 1 sack of cement and 0.5 feet of bentonite on top of sand pack; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL S-12
(installed 12/07/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Silt and sand, with some clay and a few pebbles, brown color; probably represents fill
5.0 - 6.5	2-2-2	Silt, sand, clay, and a few rock fragments, brown color; may be natural
10.0 - 11.5	2-2-2	Clay with some silt, very soft and plastic, grey to green color; probably natural; sample is damp
15.0 - 16.5	4-3-5	Silt, fine sand, and some clay, brown color, becoming more sandy and grey colored toward base
20.0 - 21.5	5-4-5	Silt and sand, with some clay and a few pebbles, brown color
25.0 - 26.5	5-8-7	Sand, medium, and pebbles, with some silt, brown color; hit water at about 26.5 feet
30.0 - 31.5	4-3-6	Sand, medium, and pebbles, brown color
35.0 - 36.5	4-4-6	Sand, medium to coarse, and pebbles, brown color
40.0 - 41.5	9-5-10	Sand, medium to coarse, and small pebbles, brown color
45.0 - 46.5	7-8-10	Sand, medium to coarse, brown color

WELL MW-12 (Cont)
(installed 12/07/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	7-11-17	Sand, medium, with small pebbles, brown color
55.0 - 56.5	23-37-34	Sand, medium to coarse, and pebbles, brown color
60.0 - 61.5	16-22-19	Sand, medium to coarse, and a few pebbles, brown color
65.0 - 66.5	21-18-51/5"	Sand, medium to coarse, and some pebbles, brown color
66.5 - 67.0	-	Bedrock at about 66.5 feet; auger refusal at about 67 feet

Borehole depth: 67 feet
Well depth: 67 feet
Screened interval: 67 to 27 feet
Well construction: 27 feet of 2-inch-diameter PVC casing over 40 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 15 feet; 1 sack cement and 0.5 feet of bentonite on top of cave-in; formation cuttings to about 4 feet; cement up to ground level; protective cover installed

WELL MW-13
(installed 12/07/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 25.0	-	No sampling attempted because this zone is comprised of fill and rubble, i.e., brick, cinders, carbon, etc.
25.0 - 26.5	3-13-19	Silt, sand, and clay, with a few small pebbles, brown color; probably natural; fill/natural contact believed to be between 20 and 25 feet
30.0 - 31.5	5-6-7	Silt and fine sand, with some clay, brown color
35.0 - 36.5	5-4-4	Silt and fine sand, with some clay, brown color
40.0 - 41.5	3-3-4	Silt and fine sand, with some clay, brown color
45.0 - 46.5	WOH-2-2	Silt, fine sand, and clay, brown color
50.0 - 51.5	WOH-4-5	Sand, fine, and silt, with some clay, brown color; hit water at about 48 feet
55.0 - 56.5	2-4-7	Sand, fine, with silt, brown color
60.0 - 61.5	3-4-9	Sand, fine, and silt with some clay, brown color
65.0 - 66.5	24-27-28	Pebbles and medium to coarse sand, brown color
70.0 - 71.5	7-9-14	Pebbles and medium to coarse sand, with minor silt, brown color

WELL MW-13 (Cont)
(installed 12/07/83)

Sample Depth Interval (ft)	Blow Count	Description
75.0 - 76.5	7-7-9	Sand, medium to coarse, with some pebbles and some black (peat type) material at base of sample, brown color
80.0 - 81.5	10-12-14	Sand, medium to coarse, brown color
85.0 - 86.5	29-34-40	Sand, medium to coarse, with pebbles and some rock fragments, brown color; decomposed rock towards base
88.0	-	Bedrock probably at about 88 feet; driller did not want to stress augers until refusal

Borehole depth: 88 feet
Well depth: 87 feet
Screened interval: 87 to 57 feet
Well construction: 57 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 49 feet; sand pack to about 44 feet; cave-in to about 25 feet; 1 sack of cement and 0.5 feet of bentonite on top of cave-in; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-14
(installed 12/08/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Sand, silt, rock fragments, and some brick, dark brown color; probably represents fill
5.0 - 6.5	6-2-3	Sand, silt, pebbles, and some slag, dark brown color; probably represents fill
10.0 - 11.5	1-2-8	Silt with some very fine sand, a few pebbles, and some clay, brown color; probably natural
15.0 - 16.5	3-2-3	Silt and fine sand, with a few pebbles, and minor clay, brown color
20.0 - 21.5	3-2-3	Clay with silt, and some sand and pebbles, grey color; could also be called silt with clay
25.0 - 26.5	2-1-2	Silt and clay, with some sand and pebbles, dark brown to grey color; very poor recovery
30.0 - 31.5	3-2-4	Clay with some silt, soft and plastic, grey color
35.0 - 36.5	4-6-9	Clay with some silt, soft and plastic, mottled green to grey color; pushed Shelby tube from 35 to 37 feet with full recovery
40.0 - 41.5	4-5-6	Clay with some silt, mottled green to grey color
45.0 - 46.5	5-12-16	Sand, medium, with pebbles, brown to grey color; tip of sample is wet

WELL MW-14 (Cont)
(installed 12/08/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	8-10-13	Sand, medium to coarse, with some pebbles, brown color; hit water at about 44 feet
55.0 - 56.5	2-4-10	Sand, medium to coarse, and pebbles, brown color
60.0 - 61.5	6-11-17	Sand, medium to coarse, and small pebbles, brown color
65.0 - 66.5	15-14-12	Sand, medium to coarse, and some pebbles, brown color
70.0 - 71.5	17-23-24	No recovery; probably same as above
75.0 - 76.5	12-19-25	Sand, medium to coarse, and pebbles, brown color
80.0 - 81.5	12-12-12	Sand, medium to coarse, brown color
85.0 - 86.0	51/1"	Bedrock at about 85.5 feet; auger refusal at about 86 feet; no recovery from sampling attempt

Borehole depth: 86 feet
Well depth: 86 feet
Screened interval: 86 to 46 feet
Well construction: 46 feet of 2-inch-diameter PVC casing over 40 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 13 feet; 0.5 feet of bentonite on top of cave-in; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-15
(installed 12/12/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Cinder type material with silt and pebbles, black color; probably represents fill
5.0 - 6.5	5-6-7	Sand, medium, and some pebbles, black (peat type) material towards base, brown to tan color, probably natural
10.0 - 11.5	5-7-10	Sand, medium, with some pebbles, brown to tan color
15.0 - 16.5	6-9-8	Sand, medium, with some pebbles, brown to tan color
20.0 - 21.5	7-13-19	Sand, medium, with some pebbles and minor silt, brown to tan color
25.0 - 26.5	13-19-19	Sand, medium, with pebbles and a few rock fragments, brown to tan color
30.0 - 31.5	15-17-20	Sand, medium, with pebbles, tan color
35.0 - 36.5	6-9-19	Sand, medium to fine, with some pebbles and a layer (about 1 inch thick) of black (peat type) material, brown to tan color
40.0 - 41.5	16-23-26	Sand, medium to coarse, with pebbles and minor silt, brown color
45.0 - 46.5	7-8-8	Sand, medium to coarse, with some pebbles and minor silt, brown color; hit water at about 42 feet

WELL MW-15 (Cont)
(installed 12/12/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	6-9-14	Sand, medium to coarse, and pebbles, brown color
55.0 - 56.0	40-51/2"	Bedrock at about 55 feet; auger refusal at about 56 feet; sample consisted of decomposed rock, brown color

Borehole depth: 56 feet
Well depth: 56 feet
Screened interval: 56 to 36 feet
Well construction: 36 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 18 feet; 0.5 feet of bentonite on top of cave-in; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-16
(installed 12/12/83 to 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Silt, with some clay and minor sand, brown color; probably mostly represents fill
5.0 - 6.5	2-5-9	Clay, with silt, a few pebbles, and some cinder-type material, brown color; probably represents fill
10.0 - 11.5	7-7-7	Pebbles, with sand and silt, brown color; probably natural
15.0 - 16.5	6-9-7	Sand, medium, with some pebbles and silt, brown color
20.0 - 21.5	9-14-15	Sand, medium, with pebbles and minor silt, brown color
25.0 - 26.5	8-10-10	Sand, medium, with pebbles, brown color
30.0 - 31.5	7-8-8	Sand, medium to coarse, and a few pebbles, brown color
35.0 - 36.5	12-18-24	Sand, medium, with some pebbles and a few rock fragments, brown color
40.0 - 41.5	27-24-28	Sand, medium, with some pebbles and a few rock fragments, brown color
45.0 - 46.5	16-17-24	Sand, medium, with some pebbles and rock fragments, brown color
50.0 - 51.5	11-20-27	Sand, medium, and pebbles, with minor silt, brown color; hit water at about 50 feet

WELL MW-16 (Cont)
(installed 12/12/83 to 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
55.0 - 56.5	23-25-27	Sand, medium, and pebbles, with minor silt, brown color
60.0 - 61.5	16-19-18	Sand, medium to coarse, and a few small pebbles, brown color
65.0 - 66.5	11-17-18	Sand, medium to coarse, with pebbles, brown color
70.0 - 71.5	11-13-21	Sand, medium to coarse, and a few pebbles, brown color
75.0 - 76.5	21-11-9	Sand, medium, with a few pebbles, and a zone (about 1 inch thick) of black (peat type) material, brown color
80.0 - 81.5	26-28-24	Sand, medium to coarse, brown color, changing to saprolite (decomposed rock) resembling a sandstone remnant; change at about 81.5 feet
84.0	-	Bedrock and auger refusal at about 84 feet

Borehole depth: 84 feet
Well depth: 81.5 feet
Screened interval: 81.5 to 46.5 feet
Well construction: 46.5 feet of 2-inch-diameter PVC casing over 35 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 31 feet; sand pack to about 30 feet; 0.5 feet of bentonite on top of sand pack; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-17
(installed 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Cinder type material with pebbles and silt, brown color; probably mostly represents fill
5.0 - 6.5	4-3-2	Sand, medium to coarse, pebbles and silt, brown color
10.0 - 11.5	4-6-7	Sand, medium, with pebbles, brown color
15.0 - 16.5	5-6-6	Sand, medium, with pebbles, brown color
20.0 - 21.5	7-8-5	Sand, medium, with pebbles and some black (peat type) material, brown color
25.0 - 26.5	10-10-13	Sand, medium, with some pebbles and some black (peat type) material, brown color
30.0 - 31.5	12-23-33	Sand, medium to coarse, and pebbles, brown color
35.0 - 36.5	24-44-49	Sand, medium, with pebbles and rock fragments, brown color
40.0 - 41.5	11-16-22	Sand, fine, with a few pebbles and some black (peat type) material, brown color; hit water at about 40 feet
45.0 - 46.5	14-20-20	Sand, medium, and pebbles, brown color
50.0 - 51.5	11-11-15	Sand, medium to coarse, and small pebbles, brown color

WELL MW-17 (Cont)
(installed 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
55.0 - 56.5	9-13-16	Sand, medium to coarse, and small pebbles, brown color
60.0 - 61.5	14-31-24	Sand, medium, and some pebbles, brown color
65.0 - 66.5	11-23-22	Sand, medium, with some pebbles, changing to hard silty clay at base, brown color; change at about 66 feet
70.0 - 71.5	11-31-51/2"	Sand, medium to coarse, and pebbles, changing to hard sandy clay (probably decomposed rock), brown color; change at about 71 feet
75.0 - 76.5	15-31-51/1"	Clay, dense, hard, and stiff, grey to brown color; probably represents decomposed rock
77.0	-	Bedrock and auger refusal at about 77 feet

Borehole depth: 77 feet
Well depth: 76 feet
Screened interval: 76 to 36 feet
Well construction: 36 feet of 2-inch-diameter PVC casing over 40 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 5 feet; cement up to ground level; protective cover installed; owing to weather conditions, there was standing surface water (a few inches up to a foot) all around this location, so a gravel (10 tons) pad was installed at the drilling location

WELL MW-18
(installed 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Sand, medium, and pebbles, brown color; probably natural
5.0 - 6.5	7-9-6	Sand, medium, with some pebbles, brown color
10.0 - 11.5	4-6-8	Sand, medium, with minor amounts of black (peat type) material, brown color
15.0 - 16.5	8-17-14	Sand, medium with one large rock fragment, brown color
20.0 - 21.5	8-13-17	Sand, medium, with some pebbles, brown color
25.0 - 26.5	9-7-7	Sand, medium, with a few pebbles and rock fragments, and minor amounts of black (peat type) material, brown color
30.0 - 31.5	7-9-11	Sand, medium to coarse, with some rock fragments and pebbles and a few rock fragments, brown color
35.0 - 36.5	11-10-14	Sand, medium, with some pebbles and a few rock fragments, brown color
40.0 - 41.5	9-10-12	Sand, medium to coarse, with pebbles and minor silt, brown color; hit water at about 39 feet
45.0 - 46.5	47-21-19	Sand, medium to coarse, with pebbles and some silt, brown color; driller thought he had augered through cobbles from about 40 to 45 feet

WELL MW-18 (Cont)
(installed 12/13/83)

Sample Depth Interval (ft)	Blow Count	Description
50.0 - 51.5	15-26-38	Sand, medium, with silt, pebbles, and a few rock fragments, brown color
55.0 - 56.0	35-51/5"	Decomposed rock (saprolite), hard and friable, grey color; may represent weathered shale
59.0	-	Bedrock and auger refusal at about 59 feet

Borehole depth: 59 feet
Well depth: 59 feet
Screened interval: 59 to 39 feet
Well construction: 39 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 18 feet; 0.5 feet of bentonite on top of cave-in; formation cuttings to about 5 feet; cement up to ground level; protective cover installed.

WELL MW-19
(installed 12/14/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Clay, with some silt, brown color; probably natural
5.0 - 6.5	5-16-16	Clay, with some silt and a few pebbles, brown color; probably natural
10.0 - 11.5	6-4-6	Silt and pebbles, brown color
15.0 - 16.5	5-8-8	Sand, medium, and a few pebbles, brown color
20.0 - 21.5	4-6-6	Sand, medium to coarse, with a few pebbles and a thin layer of black (peat type) material, brown color
25.0 - 26.5	4-9-18	Sand, medium to coarse, with a few pebbles and a thin layer of black (peat type) material, brown color
30.0 - 31.5	10-13-14	Sand, medium to coarse, and rock fragments (broken pebbles), brown color
35.0 - 36.5	30-38-50	Sand, medium, and pebbles, brown to tan color
40.0 - 41.5	16-24-24	Sand, medium to coarse, and pebbles, brown color
45.0 - 46.5	19-13-12	Sand, medium to coarse, with pebbles and a few rock fragments, brown color; hit water at about 45 feet
50.0 - 51.5	21-21-23	No recovery, probably mainly sand
55.0 - 56.5	8-3-3	Sand, medium to coarse, with a few pebbles, brown color

WELL MW-19 (Cont)
(installed 12/14/83)

Sample Depth Interval (ft)	Blow Count	Description
60.0 - 61.5	6-9-12	Sand, medium to coarse, with some silt, and clay toward base, brown color
63.0 - 64.0	-	Bedrock and auger refusal at about 64 feet; probably encountered decomposed rock at about 62 feet; material on lead auger looked like decomposed grey shale

Borehole depth: 64 feet
Well depth: 64 feet
Screened interval: 64 to 44 feet
Well construction: 44 feet of 2-inch-diameter PVC casing over 20 feet of 2-inch-diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 31 feet; sand pack to about 29 feet; 1 foot of bentonite on top of sand pack; formation cuttings to about 5 feet; cement up to ground level; protective cover installed

WELL MW-20
(installed 12/14/83)

Sample Depth Interval (ft)	Blow Count	Description
0.0 - 1.5	grab	Clay, with some silt, brown color; probably natural
5.0 - 6.5	4-5-7	Clay, with minor silt, fairly dense and stiff, brown color
10.0 - 11.5	4-5-7	Clay, with minor silt, fairly dense and stiff, brown color; clay is similar in appearence to that observed at MW-8, but appears to be less silty than clays found at the MW-12 and MW-13 locations
12.0 - 14.0	-	Pushed Shelby tube with no recovery
15.0 - 17.0	-	Pushed Shelby tube with full recovery; material consists of clay with some silt, brown color
20.0 - 21.5	-	Silt and clay, with very fine sand, very soft and plastic, brown color; sample taken from auger run-up
25.0 - 26.5	4-3-3	Silt and clay, with very fine sand, very soft and plastic, brown color
30.0 - 31.5	9-16-20	Silt, with clay and very fine sand, changing to sand and pebbles, with some silt, brown color; change at about 31 feet
35.0 - 36.5	9-12-18	Pebbles with coarse sand, brown color

WELL MW-20
(installed 12/14/83)

Sample Depth Interval (ft)	Blow Count	Description
40.0 - 41.5	9-17-18	Pebbles with medium to coarse sand, brown color
45.0 - 46.5	14-13-17	Sand, medium to coarse, with pebbles, brown color
50.0 - 51.5	9-25-30	Sand, medium to coarse, brown color; base of sample resembles decomposed sandstone
55.0 - 56.5	27-23-31	Sand, medium, with rock fragments toward base, brown color
60.0 - 61.5	23-32-23	Sand, medium, with some pebbles and rock fragments toward base, brown color
65.0	-	Bedrock and auger refusal at about 65 feet

Borehole depth: 65 feet
Well depth: 64 feet
Screened interval: 64 to 34 feet
Well construction: 34 feet of 2-inch-diameter PVC casing over 30 feet of 2-inch diameter, 0.010-inch-slot PVC screen; about 2 feet of PVC stick-up
Comments: Cave-in to about 20 feet; 1 foot bentonite on top of cave in; formation cuttings and more cave-in to about 9 feet; 1 foot of bentonite on top of formation cuttings; cement up to ground level (i.e., about 7 to 8 feet of cement; protective cover installed; due to weather conditions, surface water is several inches deep all around this location

APPENDIX B

Soil-Testing Results
Ormet Corporation
Hannibal, Ohio

APPENDIX B

ʌTS OF FALLING-HEAD PERMEABILITY TESTS AND CATION EXCHANGE ANALYSES

Sample Depth Interval (ft)	Cation Exhange Capacity (meq/100g)	Natural Moisture Content (percent)	Falling-Head Permeability K (cm/sec)	Sample Description
10.0 - 11.5	7.6	-	-	Soft silty clay
45.0 - 46.5	5.7	-	-	Clayey sandy silt
40.0 - 41.5	6.9	-	-	Silty clay
10.0 - 11.5	10.3	-	-	Clay, with minor silt
35.0 - 37.0	-	23.5	3.00×10^{-8}	Soft silty clay
15.0 - 17.0	-	21.6	9.02×10^{-8}	Silty clay

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APPENDIX C

Water-Level Data
Ormet Corporation,
Hannibal, Ohio

C-1 Results of 1983-1984 Water-Level Measurements From MW-Series and TH-Series Wells

C-2 Median Values from 1972 Water-Level Measurements From TH-Series Wells

Geraghty & Miller, Inc.

Appendix C-1

Water-Level Data From 1983-1984 Measurements at MW-Series and TH-Series Monitor Wells

Well Number	Elevation of Measuring Point (ft above MSL)	December 28, 1983 Depth to Water Below Measuring Point (ft)	December 28, 1983 Elevation of Water (ft above MSL)	January 31, 1984 Depth to Water Below Measuring Point (ft)	January 31, 1984 Elevation of Water (ft above MSL)
MW-1	668.33	54.96	613.37	54.93	613.40
MW-2	668.11	60.29	607.82	60.20	607.91
MW-3	645.20	39.67	605.53	37.58	607.62
MW-4	661.09	63.75	597.34	62.70	598.39
MW-5	668.17	69.05	599.12	68.23	599.94
MW-6	*	*	*	*	*
MW-7	667.94	61.73	606.21	60.88	607.06
MW-8	667.76	76.85	590.91	75.31	592.45
MW-9	666.63	75.70	590.93	74.01	592.62
MW-10	667.20	77.18	590.02	75.47	591.73
MW-11	667.30	69.04	598.26	68.12	599.18
MW-12	636.77	25.62	611.15	25.71	611.06
MW-13	661.43	44.15	617.28	44.15	617.28
MW-14	653.66	40.63	613.03	40.73	612.93
MW-15	657.26	40.57	616.69	40.90	616.36
MW-16	662.68	51.32	611.36	51.49	611.19
MW-17	654.99	41.88	613.11	41.93	613.06
MW-18	660.85	40.52	620.33	40.42	620.43
MW-19	661.94	43.59	618.35	44.00	617.94
MW-20	632.33	12.90	619.43	12.97	619.36
TH-3	667.82	61.60	606.22	61.36	606.46
TH-10	658.17	-	-	40.51	617.66
TH-11	658.75	-	-	37.07	621.68
TH-15	663.65	72.83	590.82	71.32	592.33
TH-16	664.68	73.33	591.35	71.20	593.48
TH-17	663.96	72.63	591.33	70.78	593.18
8-inch	664.62	51.00	613.62	51.16	613.46
River (RP-1)	643.17	20.3	622.9	19.5	623.7

* No well installed

\- No measurement collected

Note: Water level measurements (except measurements of MW-9, TH-15, TH-16, and TH-17, 1/31/84, collected with an M-scope) collected using steel tape/chalk method; measuring point for 2-inch diameter wells is top of PVC casing; measuring point of 6-inch and larger diameter wells is top of steel casing; measuring point for river is top of steel beam along a walkway.

APPENDIX C-2

MEDIAN WATER-LEVEL DATA FROM TH-SERIES MONITOR WELLS

Well Number	Time Span	Total Number of Measurements	Median Depth to Water (ft)	Median Water Elevation (ft)
TH-0	2/18/72 - 9/13/72	10	84.31	581.69
TH-1	1/19/72 - 9/13/72	17	80.78	583.22
TH-3	1/6/72 - 9/13/72	18	70.79	596.70
TH-4	1/13/72 - 9/13/72	13	40.33	611.43
TH-5	1/18/72 - 9/13/72	15	50.22	603.52
TH-6	1/6/72 - 9/13/72	14	41.88	604.48
TH-7	1/13/72 - 9/13/72	9	52.80	605.39
TH-8	1/13/72 - 9/13/72	18	46.31	603.26
TH-9	1/13/72 - 9/13/72	15	44.89	603.51
TH-10	1/19/72 - 9/13/72	14	43.36	614.81
TH-11	1/19/72 - 9/13/72	15	37.11	621.64
TH-12	2/18/72 - 9/13/72	7	36.12	602.43
TH-13	2/23/72 - 9/13/72	5	28.42	602.88
TH-14	-	-	Dry Hole	-
TH-14A	7/25/72 - 9/13/72	5	49.79	603.58
TH-15	7/11/72 - 9/13/72	8	78.52	585.08
TH-16	6/30/72 - 9/13/72	9	78.49	585.83
TH-17	6/30/72 - 9/13/72	9	77.88	585.67
TH-18	-	-	Dry Hole	-
TH-19	7/11/72 - 9/13/72	8	79.40	583.23
8-inch	1/26/72 - 9/13/72	12	51.58	602.67
River	7/72	1	-	602.6

APPENDIX D

Groundwater-Quality Analyses
Ormet Corporation
Hannibal, Ohio

APPENDIX D-1: SAMPLE SET 1

RESULTS OF DECEMBER 1983 FIELD ANALYSES OF GROUNDWATER SAMPLES
FROM MW-SERIES MONITOR WELLS

Well Number	Date Sampled	Temperature (°C)	pH (std. units)	Specific Conductance (umhos/cm)	Comments
MW-1	12/29/83	11	6.0	210	
MW-2	12/30/83	11	10.3	6,000	Sample is dark coffee color
MW-3	12/30/83	15	6.1	710	
MW-4	12/31/83	15	6.6	490	Couldn't get pump down well- sample was bailed
MW-5	12/29/83	12	9.5	2,825	Sample is dark coffee color
MW-7	12/29/83	22	6.2	700	
MW-8	12/29/83	13	9.2	700	Sample is tea color
MW-9	12/29/83	13	7.2	600	
MW-10	12/31/83	28	7.6	1,280	Couldn't get pump down well- sample was bailed
MW-11	12/29/83	13	9.4	825	Sample is tea color
MW-12	12/31/83	13	7.3	400	
MW-13	12/31/83	15	7.2	463	
MW-14	12/31/83	13	7.8	395	
MW-15	12/30/83	11	6.7	435	
MW-16	12/30/83	12	9.9	1,800	Sample is coffee color
MW-17	12/31/83	11	7.6	475	
MW-18	12/30/83	11	10.0	8,750	Sample is coffee color
MW-19	12/30/83	10	7.1	435	
MW-20	12/30/83	13	6.6	420	
TH-3	12/30/83	-	8.1*	345*	

*Samples not thought to be truly representative due to insufficient well evacuation

APPENDIX D-1: SAMPLE SET 2

RESULTS OF FEBRUARY 1984 FIELD ANALYSES OF GROUNDWATER SAMPLES FROM MW-SERIES MONITOR WELLS

Well Number	Date Sampled	Temperature (°C)	pH (std. units)	Specific Conductance (umhos/cm)	Comments
MW-1	2/2/84	14	6.1	215	
MW-2	2/4/84	11	10.3	2,750	Sample is dark coffee color
MW-3	2/2/84	16	6.3	625	
MW-4	2/2/84	13	6.8	525	Could not get pump down well- sample was bailed
MW-5	2/1/84	12	9.6	2,700	Sample is dark coffee color
MW-7	2/2/84	31	5.9	750	
MW-8	2/2/84	13	9.5	700	Sample is tan color
MW-9	2/2/84	15	7.3	600	
MW-10	2/4/84	23	7.5	800	Could not get pump down well- sample was bailed
MW-11	2/1/84	12	9.5	775	Sample is tea color
MW-12	2/3/84	14	7.2	385	
MW-13	2/3/84	16	7.1	430	
MW-14	2/3/84	14	7.8	402	
MW-15	2/3/84	13	6.7	435	
MW-16	2/1/84	12	9.7	1,550	Sample is coffee color
MW-17	2/3/84	13	7.4	470	
MW-18	2/1/84	12	9.8	7,500	Sample is coffee color
MW-19	2/4/84	11	6.8	405	
MW-20	2/4/84	13	6.5	365	

APPENDIX D-2: Sample Set 1

Results of Laboratory Analyses of December, 1983 Groundwater Samples from MW-Series Monitor Wells

(samples collected 12/29/83 to 12/31/83; all values expressed in mg/l unless otherwise specified)

Sample Location	MW-1	MW-2	MW-3	MW-4	MW-5	MW-7	MW-8	MW-9	MW-10	MW-11
Transmittance (%) (1)	100	0	99	100	2	100	92	99	99	85
Field Temperature (°C)	11	11	15	15	12	22	13	13	28	13
pH (std. units)	6.4	10.3	6.5	7.1	9.7	6.8	9.5	7.7	7.7	9.6
Conductivity (umhos/cm) (1)	270	6000	752	613	3058	613	820	704	1205	980
Total Organic Carbon	1.4	800	2.9	3.9	260	2.3	9.4	36	5.1	23
Total Dissolved Solids	226	7560	613	411	3040	466	625	487	854	805
Total Alkalinity ($CaCO_3$)	59	3980	357	249	1340	84	305	250	246	368
Bicarbonate (HCO_3)	72	1440	436	304	952	100	226	305	300	285
Carbonate (CO_3)	0	1680	0	0	336	0	72	0	0	80
Hydroxide (OH)	0	0	0	0	0	0	0	0	0	0
Chloride	37	500*	31	32	500*	126	27	30	75	33
Fluoride	0.1	400	0.1	1.6	130	0.1	18	6.8	6.9	33
Nitrate Nitrogen	0.1	1.6	0.1	2.2	17	<0.1	2.2	1.6	6.5	2.8
Sulfate	19	263	166	60	457	57	95	91	288	77
Sodium	14.2	1950	39.2	41.5	880	49.0	202	111	195	238
Potassium	1.3	4.3	1.2	3.2	4.5	2.7	1.4	2.3	8.0	1.6
Calcium	33.3	20.6	144	88	10.4	61	3.5	60	95	2.9
Magnesium	6.8	2.0	15.2	14.9	2.1	13.1	0.6	6.0	8.7	0.3
Iron	0.04	55.2	0.92	0.06	17.5	1.01	0.20	0.12	0.60	0.48
Manganese	0.65	1.98	5.06	4.76	1.61	7.88	0.01	<0.01	0.26	0.06
Aluminum	<0.1	6.6	0.1	<0.1	4.1	<0.1	0.5	<0.1	0.1	0.8
Silica (SiO_2)	25	190	22	12	55	40	15	17	25	13
Total Cyanide (1)	0.018	56.0	0.25	0.041	18.8	0.019	0.32	0.41	1.36	0.52
Free Cyanide (1)	0.014	0.27	0.014	0.011	0.064	0.020	0.017	0.013	0.083	0.021
Ammonia (1)	0.098	<0.001	<0.001	0.008	20.0	0.338	2.25	0.268	0.027	3.05
Na/Cl Ratio	0.38	3.90	1.26	1.30	1.76	0.39	7.48	3.70	2.60	7.21
%Charge Imbalance	4.4	16.6	6.1	2.0	18.9	0.6	4.0	1.6	2.7	4.8

(1) Parameter analyzed by Ormet Laboratory; all other parameters analyzed by Martèl Laboratory Services, Inc. (of Baltimore, Maryland) unless otherwise specified.

* Analytical results reported to one significant figure due to high background interferences.

\- Not analyzed

0 Below detection

Note: All analytical methods are either from Standard Methods for the Examination of Water and Wastewater, or U.S. Environmental Protection Agency Methods of Chemical Analysis of Water and Wastes.

APPENDIX D-2: Sample Set 1 (Cont.)

Results of Laboratory Analyses of December, 1983 Groundwater Samples from MW-Series Monitor Wells

(samples collected 12/29/83 to 12/31/83; all values expressed in mg/l unless otherwise specified)

Sample Location	MW-12	MW-13	MW-14	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20	TH-3	TH-15
Transmittance (%) (1)	100	100	100	100	11	99	37	100	100	96	95
Field Temperature (°C)	13	15	13	11	12	11	11	10	13	-	-
pH (std. units)	7.5	7.2	8.0	6.9	9.8	7.9	9.9	7.2	6.7	7.5(1)	7.4(1)
Conductivity (umhos/cm) (1)	476	540	435	568	2092	613	10526	581	508	-	-
Total Organic Carbon	2.5	2.8	2.5	4.5	220	2.5	320	2.3	2.6	-	
Total Dissolved Solids	319	381	319	393	2130	403	8640	397	252	-	
Total Alkalinity ($CaCO_3$)	167	255	168	191	1020	277	6390	255	176	162(1)	1291(1)
Bicarbonate (HCO_3)	204	311	205	233	512	378	2450	311	215	198(1)	157(1)
Carbonate (CO_3)	0	0	0	0	360	0	2630	0	0	0	0
Hydroxide (OH)	0	0	0	0	0	0	0	0	0	0	0
Chloride	27	39	28	34	600*	29	700*	31	31	1.5(1)	<1.0(1)
Fluoride	2.1	1.2	3.0	0.1	110	5.6	460	0.3	0.6	-	-
Nitrate Nitrogen	1.1	4.4	0.4	2.6	8.5	2.4	0.6	0.1	0.1	-	-
Sulfate	55	99	68	68	130	71	605	57	68	-	-
Sodium	24.3	26.1	40.7	28.8	530	78	3150	22.9	24.0	-	-
Potassium	2.6	3.2	2.6	1.2	3.0	1.8	12.8	6.4	1.5	-	-
Calcium	74	76	59	112	14.6	58	13.6	109	84	-	-
Magnesium	11.8	12.5	9.9	5.3	4.4	9.3	4.1	10.5	12.0	-	-
Iron	<0.01	<0.01	0.30	0.14	12.4	0.44	58.7	<0.01	<0.01	-	-
Manganese	0.94	5.10	0.23	0.03	0.91	1.38	0.26	0.54	2.02	-	-
Aluminum	<0.1	<0.1	<0.1	<0.1	2.4	0.1	4.8	0.1	0.1	-	-
Silica (SiO_2)	14	13	14	16	53	14	230	17	14	-	-
Total Cyanide (1)	0.074	0.22	0.16	0.44	7.35	0.99	110.0	0.068	0.050	0.41	34
Free Cyanide (1)	0.021	0.021	0.016	0.018	0.034	0.021	0.45	0.013	0.025	0.054	0.091
Ammonia (1)	0.072	0.100	0.038	0.020	<0.001	0.002	<0.001	<0.001	<0.001	-	-
Na/Cl Ratio	0.90	0.67	1.45	0.85	0.88	2.69	4.50	0.74	0.77	-	-
%Charge Imbalance	3.9	16.0	1.2	8.1	30.9	10.6	14.3	1.9	3.3	-	-

(1) Parameter analyzed by Ormet Laboratory; all other parameters analyzed by Martel Laboratory Services, Inc. (of Baltimore, Maryland) unless otherwise specified.

* Analytical results reported to one significant figure due to high background interferences.

\- Not analyzed

0 Below detection

Note: All analytical methods are either from Standard Methods for the Examination of Water and Wastewater, or U.S. Environmental Protection Agency Methods of Chemical Analysis of Water and Wastes.

APPENDIX D-2: Sample Set 2

Results of Laboratory Analyses of February, 1984 Groundwater Samples from MW-Series Monitor Wells

(samples collected 02/01/84 to 02/04/84; all values expressed in mg/l unless otherwise specified)

Sample Location	MW-1	MW-2	MW-3	MW-4	MW-5	MW-7	MW-8	MW-9	MW-10	MW-11
Transmittance (%)(1)	99	0	98	99	1	98	91	99	99	58
Field Temperature (°C)	14	11	16	13	12	31	13	15	23	12
pH (std. units)	6.1	10.3	6.2	6.9	9.6	5.9	9.5	7.7	7.6	9.6
Conductivity (umhos/cm) (1)	270	7752	725	625	3636	581	820	645	820	962
Total Organic Carbon	0.7	1600	2.0	4.7	230	1.4	4.5	1.7	3.4	17
Total Dissolved Solids	226	6890	514	426	3030	398	628	483	593	778
Total Alkalinity ($CaCO_3$)	53	4140	189	263	1410	65	316	259	224	387
Bicarbonate (HCO_3)	64	1220	230	321	1010	79	234	316	273	323
Carbonate (CO_3)	0	1880	0	0	348	0	74	0	0	73
Hydroxide (OH)	0	0	0	0	0	0	0	0	0	0
Chloride	38	1200	32	34	750	125	37	25	47	45
Fluoride	0.1	420	0.3	1.5	120	0.1	18	6.6	5.5	27
Nitrate Nitrogen	0.1	2.8	0.1	2.4	0.8	<0.1	<0.1	1.3	3.3	<0.1
Sulfate	31	329	169	69	565	55	80	80	183	101
Sodium	14.9	2290	41.5	39.2	1030	49.2	199	106	106	232
Potassium	1.2	3.4	1.7	3.1	4.7	2.2	1.2	2.0	3.2	4.1
Calcium	32.8	20.7	103	75	9.9	44.2	2.1	51	78	3.3
Magnesium	3.6	2.2	15.4	14.4	3.6	11.3	1.1	5.7	7.6	2.9
Iron	0.01	58	0.83	<0.01	18.0	9.0	0.23	0.10	0.30	7.9
Manganese	0.54	2.46	3.55	4.09	1.39	4.72	0.04	0.02	0.26	0.37
Aluminum	0.1	6.0	0.1	0.1	9.5	0.1	0.5	0.2	0.2	20
Silica (SiO_2)	24	100	19	11	63	42	12	15	20	44
Total Cyanide (1)	0.04	48.0	0.16	<0.01	14.5	<0.01	0.14	0.22	0.79	0.25
Free Cyanide (1)	-	-	-	-	-	-	-	-	-	-
Ammonia (1)	0	0	0	0	0	0	0	0	3.4	0
Na/Cl Ratio	0.39	1.91	1.30	1.15	1.37	0.39	5.38	4.24	2.26	5.16
%Charge Imbalance	3.0	18.1	0.2	7.1	19.2	5.7	5.8	1.5	3.7	8.4

(1) Parameter analyzed by Ormet Laboratory; all other parameters analyzed by Martel Laboratory Services, Inc. (of Baltimore, Maryland) unless otherwise specified.

\- Not analyzed

0 Below detection

Note: All analytical methods are either from Standard Methods for the Examination of Water and Wastewater, or U.S. Environmental Protection Agency Methods of Chemical Analysis of Water and Wastes. Analysis for silica, TOC, and aluminum performed on NaOH-preserved samples have been omitted because of analytical inaccuracy.

Geraghty & Miller, Inc.

APPENDIX D-2: Sample Set 2 (Cont.)

Results of Laboratory Analyses of February, 1984 Groundwater Samples from MW-Series Monitor Wells

(samples collected 02/01/84 to 02/04/84; all values expressed in mg/l unless otherwise specified)

Sample Location	MW-12	MW-13	MW-14	MW-15	MW-16	MW-17	MW-18	MW-19	MW-20	TH-3	TH-15
Transmittance (%)(1)	99	99	99	99	2	99	32	99	99	-	-
Field Temperature (°C)	14	16	14	13	12	13	12	11	13	-	-
pH (std. units)	7.5	7.5	8.1	6.9	9.7	7.6	9.8	7.1	6.6	7.4(1)	7.5(1)
Conductivity (umhos/cm) (1)	476	524	500	550	2049	581	9615	575	501	556	476
Total Organic Carbon	1.4	1.8	1.7	1.4	190	1.6	170	1.2	2.1	-	-
Total Dissolved Solids	305	352	327	382	1880	371	7440	369	335	-	-
Total Alkalinity ($CaCO_3$)	141	137	152	188	1010	228	5570	243	166	171(1)	176(1)
Bicarbonate (HCO_3)	172	167	185	229	732	278	2670	296	203	-	-
Carbonate (CO_3)	0	0	0	0	246	0	2028	0	0	-	
Hydroxide (OH)	0	0	0	0	0	0	0	0	0	-	
Chloride	29	38	31	34	367	29	400	29	33	36(1)	43(1)
Fluoride	2.0	1.9	3.1	0.1	98	4.4	350	0.5	0.5	3.4(1)	1.0(1)
Nitrate Nitrogen	0.6	0.4	1.2	2.7	5.5	0.5	0.3	0.1	<0.1	-	-
Sulfate	85	113	94	80	161	69	665	67	75	-	-
Sodium	23.8	31.2	52	29.4	570	52	2750	20.2	22.9	-	-
Potassium	2.5	2.4	2.5	1.3	3.9	1.7	13.0	6.9	1.7	-	-
Calcium	66	68	54	94	22.1	69	8.2	97	76	-	-
Magnesium	11.6	11.1	8.8	5.1	6.8	11.1	4.7	10.5	12.1	-	-
Iron	0.02	0.14	0.06	0.13	13.9	0.39	61	0.05	0.04	-	-
Manganese	0.71	2.25	0.16	<0.01	1.41	1.77	0.50	0.26	1.99	-	-
Aluminum	0.2	0.2	0.2	0.2	6.7	0.2	15	0.2	0.2	-	-
Silica (SiO_2)	14	13	13	16	58	12	110	13	14	-	-
Total Cyanide (1)	0.02	0.34	0.15	0.51	5.5	1.03	52.0	0.04	0.04	0.16	<0.01
Free Cyanide (1)	-	-	-	-	-	-	-	-	-	-	-
Ammonia (1)	3.7	2.9	2.4	0	0	3.8	0	0.2	1.8	0	0
Na/Cl Ratio	0.82	0.82	1.68	0.86	1.55	1.79	6.88	0.70	0.69	-	-
%Charge Imbalance	1.8	1.7	2.5	0.2	19.1	2.9	12.4	2.5	0.2	-	

(1) Parameter analyzed by Ormet Laboratory; all other parameters analyzed by Martel Laboratory Services, Inc. (of Baltimore, Maryland) unless otherwise specified.

\- Not analyzed

0 Below detection

Note: All analytical methods are either from Standard Methods for the Examination of Water and Wastewater, or U.S. Environmental Protection Agency Methods of Chemical Analysis of Water and Wastes. Analysis for silica, TOC, and aluminum performed on NaOH-preserved samples have been omitted because of analytical inaccuracy.

APPENDIX D-3

RESULTS OF LABORATORY ANALYSES OF 1972 GROUNDWATER SAMPLES
FROM TH-SERIES MONITOR WELLS

Test Hole	February 1972 pH	February 1972 Fluor. ppm.	February 1972 % Trans.	February 1972 Temp. °F	July 1972 pH	July 1972 Fluor. ppm.	July 1972 % Trans.	July 1972 Cl. ppm	July 1972 Temp. °F
TH-0	7.9	1.6	92	55	8.0	1.0	96	62	58
TH-1	7.9	1.0	98	57	7.9	1.3	77	29	56
TH-3	10.1	468	0	57	10.2	325	0	443	59
TH-4	7.0	9	74	54	7.1	15	29	132	59
TH-5	10.5	980	0	59	10.4	340	0	2792	59
PW 8"	10.2	550	0	57	10.7	585	74	4100	59
TH-6	11.1	950	58	51	9.8	100	17	1817	68
TH-7	9.8	250	0	-	-	-	-	-	-
TH-8	10.4	770	0	54	10.3	520	0	647	57
TH-9	9.9	430	0	54	9.3	133	2	355	58
TH-10	7.9	10	98	-	7.9	7	2	-	59
TH-11	7.1	6	0	58	7.7	8	60	142	57
TH-12	6.9	0.82	97	58	6.9	0.25	80	19	60
TH-13	7.1	0.74	98	55	6.7	0.15	73	79	56
TH-14A	-	-	-	-	10.5	1260	0	122	69
TH-15	-	-	-	-	8.1	1.0	87	21	63
TH-16	-	-	-	-	8.2	1.0	98	27	59
TH-17	-	-	-	-	7.4	0.16	93	39	58
TH-19	-	-	-	-	8.0	1.3	96	29	56

- Not sampled

Adapted from Fred Klaer and Associates, September 27, 1972

APPENDIX D-4

AVERAGED 1982-1983 WATER-QUALITY DATA FOR THE NEW INTERCEPTOR WELL

DATE	New Interceptor Well Average pH (std. units)	Average Fluoride (ppm)	Average Trans-mittance (percent)	Average Total Cyanide (ppm)	Average Free Cyanide (ppm)
March 82	8.7	84	65	5.1	<0.15
April 82	9.0	77	69	5.5	0.14
May 82	9.0	68	76	6.7	0.1
June 82	9.0	76	76	6.0	0.01
July 82	9.0	72	74	5.9	0.12
August 82	9.0	81	70	-	-
September 82	8.8	82	69	-	-
October 82	9.0	82	71	-	-
November 82	8.9	86	71	-	-
December 82	8.9	58	74	-	-
January 83	8.8	89	66	-	-
February 83	8.8	68	66	-	-
March 83	8.8	73	71	-	-
April 83	8.7	65	78	-	-
May 83	8.8	69	70	-	-
June 83	8.8	72	65	-	-
July 83	8.8	71	66	-	-
August 83	8.7	81	65	-	-

- Not analyzed

Note: All analyses performed by Ormet Corporation laboratory

APPENDIX D-4 (CONT'D)

AVERAGED 1982-1983 WATER-QUALITY DATA FOR THE
OLD INTERCEPTOR WELL

DATE	Old Interceptor Well				
	Average pH (std. units)	Average Fluoride (ppm)	Average Trans-mittance (percent)	Average Total Cyanide (ppm)	Average Free Cyanide (ppm)
March 82	*	*	*	*	*
April 82	9.2	161	9	26.3	0.15
May 82	9.0	75	56	9.2	0.13
June 82	9.0	76	51	6.7	0.02
July 82	8.9	75	31	5.2	0.20
August 82	9.1	87	22	-	-
September 82	8.9	84	23	-	-
October 82	9.1	79	26	-	-
November 82	9.2	76	29	-	-
December 82	9.1	57	31	-	-
January 83	9.2	64	34	-	-
February 83	9.1	45	39	-	-
March 83	9.1	60	36	-	-
April 83	9.1	60	39	-	-
May 83	9.1	60	44	-	-
June 83	9.0	51	44	-	-
July 83	8.9	60	45	-	-
August 83	9.0	64	47	-	-

* No sample collected; well not pumped from 2/15/82 to 4/5/82

- Not analyzed

Note: All analyses performed by Ormet Corporation laboratory

APPENDIX D-4 (CONT'D)

AVERAGED 1982-1983 WATER-QUALITY DATA FOR THE
ORMET RANNEY WELL

DATE	Ranney Well				
	Average pH (std. units)	Average Fluoride (ppm)	Average Trans-mittance (percent)	Average Total Cyanide (ppm)	Average Free Cyanide (ppm)
March 82	8.6	25	71	4.8	<0.10
April 82	8.7	16	80	2.3	0.05
May 82	8.5	13	82	2.4	0.[illegible]
June 82	8.5	15	81	2.5	0.01
July 82	8.3	15	77	2.8	0.04
August 82	8.6	14	79	-	-
September 82	7.6	6.0	91	-	-
October 82	7.6	2.6	98	-	-
November 82	7.5	2.6	97	-	-
December 82	7.5	1.9	98	-	-
January 83	7.5	2.5	98	-	-
February 83	7.5	2.1	97	-	-
March 83	7.5	2.9	99	-	-
April 83	7.5	2.3	99	-	-
May 83	7.7	2.2	99	-	-
June 83	7.4	1.6	99	-	-
July 83	7.4	1.9	99	-	-
August 83	7.3	3.4	97	-	-

- Not analyzed

Note: All analyses performed by Ormet Corporation laboratory

APPENDIX E

Bedrock Elevation Data,
Ormet Corporation,
Hannibal, Ohio

Appendix E

Approximate Depths to and Elevations of Bedrock Beneath the Ormet Plant Site

Location	Approximate Ground Elevation (ft above MSL)	Approximate Depth to Bedrock (ft)	Approximate Bedrock Elevation (ft above MSL)
RTH-3	630	72	558
RTH-8	630	68	562
RTH-9	630	63	567
TH-1	663	>99	<564
TH-3	666	>103	<563
TH-4	650	>88	<562
TH-5	652	>85	<567
TH-6	646	>62	<584
TH-7	657	>73	<584
TH-8	649	>72	<577
TH-9	646	>79	<567
TH-10	658	55	603
TH-11	658	56	602
TH-12	635	>71	<564
TH-13	628	>65	<563
TH-14	652	55	603
TH-14A	652	69	583
TH-15	663	102	561
TH-16	663	102	561
TH-17	662	93	569
TH-18	661	83	578
TH-19	661	>101	<560
8-inch	662	>93	<569

Location	Approximate Ground Elevation (ft above MSL)	Approximate Depth to Bedrock (ft)	Approximate Bedrock Elevation (ft above MSL)
MW-1	666.3	67	599
MW-2	666.0	86	580
MW-3	643.1	76	567
MW-4	659.3	93	566
MW-5	666.2	95	571
MW-6	664.0	51	614
MW-7	666.2	77	589
MW-8	666.6	98	569
MW-9	665.2	101	564
MW-10	665.6	100	566
MW-11	665.7	96	570
MW-12	635.0	67	568
MW-13	659.3	88	571
MW-14	651.9	86	566
MW-15	655.4	55	600
MW-16	660.9	84	577
MW-17	653.8	77	577
MW-18	658.8	59	600
MW-19	660.4	64	596
MW-20	630.8	65	566

Note: Depths to and elevations of bedrock reference relatively well-indurated basement rock; several feet of weathered rock (saprolite) may be present above this basement.

APPENDIX F

Certificates of Laboratory Analyses by Martel Laboratory Services, Inc.

F-1 Certificates of Analyses of December 1983 Groundwater Samples

F-2 Certificates of Analyses of February 1984 Groundwater Samples

MARTEL

Appendix F-1

Certificate of Laboratory Analysis

Martel Laboratory Services, Inc. 1025 Cromwell Bridge Road Baltimore, Maryland 21204 (301) 825-779

Invoice Number 11903

Page ____ of ____ page(

Sample

W-4737 19 Groundwater samples picked up by Martel Laboratory Services on January 3, 1984. Second revised report (includes fluoride results.)

Geraghty & Miller, Inc.
844 West Street
Annapolis, Maryland 21401
Attn: Mr. Cleason Smith

February 28, 1984

Sample	MW-1	MW-1 NF	MW-2	MW-2 NF	MW-3
pH	6.4	----	10.3	----	6.5
Total Organic Carbon	1.4	13	800	820	2.9
Total Dissolved Solids	226	----	7560	----	613
Total Alkalinity ($CaCO_3$)	59	----	3980	----	357
Bicarbonates (HCO_3)	72	----	1440	----	436
Carbonates (CO_3)	0	----	1680	----	0
Hydroxides (OH)	0	----	0	----	0
Chloride	37	----	500*	----	31
Nitrate Nitrogen	0.1	----	1.6	----	0.1
Sulfate	19	----	263	----	166
Sodium	14.2	14.0	1950	2200	39.2
Potassium	1.3	9.1	4.3	47.5	1.2
Calcium	33.3	31.4	20.6	37.8	144
Magnesium	6.8	11.9	2.0	18.6	15.2
Iron	0.04	68.8	55.2	178	0.92
Manganese	0.65	4.67	1.98	9.88	5.06
Aluminum	<0.1	53	6.6	180	0.1
Silica (SiO2)	25	95	190	92	22
Fluoride	0.1	----	400	----	0.1

MARIEL Appendix F-1 (cont.)

Sample	MW-4	MW-5	MW-5 NF	MW-7	MW-8
pH	7.1	9.7	----	6.8	9.5
Total Organic Carbon	3.9	260	800	2.3	9.4
Total Dissolved Solids	411	3040	----	466	625
Total Alkalinity ($CaCO_3$)	249	1340	----	84	305
Bicarbonates (HCO_3)	304	952	----	100	226
Carbonates (CO_3)	0	336	----	0	72
Hydroxides (OH)	0	0	----	0	0
Chloride	32	500*	----	126	27
Nitrate Nitrogen	2.2	17	----	<0.1	2.2
Sulfate	60	457	----	57	95
Sodium	41.5	880	920	49.0	202
Potassium	3.2	4.5	9.2	2.7	1.4
Calcium	88	10.4	11.5	61	3.5
Magnesium	14.9	2.1	3.8	13.1	0.6
Iron	0.06	17.5	28.2	1.01	0.20
Manganese	4.76	1.61	2.33	7.88	0.01
Aluminum	<0.1	4.1	21	<0.1	0.5
Silica (SiO2)	12	55	62	40	15
Fluoride	1.6	130	----	0.1	18

Sample	MW-8 NF	MW-9	MW-10	MW-11	MW-11 NF
pH	----	7.7	7.7	9.6	----
Total Organic Carbon	53	36	5.1	23	24
Total Dissolved Solids	----	487	854	805	----
Total Alkalinity ($CaCO_3$)	----	250	246	368	167
Bicarbonates (HCO_3)	----	305	300	285	204
Carbonates (CO_3)	----	0	0	80	0
Hydroxides (OH)	----	0	0	0	0
Chloride	----	30	75	33	----
Nitrate Nitrogen	----	1.6	6.5	2.8	----
Sulfate	----	91	288	77	----
Sodium	214	111	195	238	256
Potassium	6.3	2.3	8.0	1.6	9.8
Calcium	4.6	60	95	2.9	3.4
Magnesium	1.9	6.0	8.7	0.3	2.2
Iron	5.54	0.12	0.60	0.48	11.6
Manganese	0.19	<0.01	0.26	0.06	0.46
Aluminum	8.7	<0.1	0.1	0.8	26
Silica (SiO2)	40	17	25	13	45
Fluoride	----	6.8	6.9	33	----

Sample	MW-12	MW-13	MW-14	MW-15	MW-16
pH	7.5	7.2	8.0	6.9	9.8
Total Organic Carbon	2.5	2.8	2.5	4.5	220
Total Dissolved Solids	319	381	319	393	2130
Total Alkalinity ($CaCO_3$)	167	255	168	191	1020
Bicarbonates (HCO_3)	204	311	205	233	512
Carbonates (CO_3)	0	0	0	0	360
Hydroxides (OH)	0	0	0	0	0
Chloride	27	39	28	34	600*
Nitrate Nitrogen	1.1	4.4	0.4	2.6	8.5
Sulfate	55	99	68	68	130
Sodium	24.3	26.1	40.7	28.8	530
Potassium	2.6	3.2	2.6	1.2	3.0
Calcium	74	76	59	112	14.6
Magnesium	11.8	12.5	9.9	5.3	4.4
Iron	<0.01	<0.01	0.30	0.14	12.4
Manganese	0.94	5.10	0.23	0.03	0.91
Aluminum	<0.1	<0.1	<0.1	<0.1	2.4
Silica (SiO_2)	14	13	14	16	53
Fluoride	2.1	1.2	3.0	0.1	110

Sample	MW-16 NF	MW-17	MW-18	MW-18 NF	MW-19
pH	----	7.9	9.9	----	7.2
Total Organic Carbon	280	2.5	320	320	2.3
Total Dissolved Solids	----	403	8640	----	397
Total Alkalinity ($CaCO_3$)	----	277	6390	----	255
Bicarbonates (HCO_3)	----	378	2450	----	311
Carbonates (CO_3)	----	0	2630	----	0
Hydroxides (OH)	----	0	0	----	0
Chloride	----	29	700*	----	31
Nitrate Nitrogen	----	2.4	0.6	----	0.1
Sulfate	----	71	605	----	57
Sodium	550	78	3150	3180	22.9
Potassium	16.5	1.8	12.8	37.0	6.4
Calcium	25.4	58	13.6	12.2	109
Magnesium	12.9	9.3	4.1	11.4	10.5
Iron	66.7	0.44	58.7	105	<0.01
Manganese	2.83	1.38	0.26	1.52	0.54
Aluminum	78	0.1	4.8	95	0.1
Silica (SiO_2)	310	14	230	280	17
Fluoride	----	5.6	460	----	0.3

Sample	MW-20
pH	6.7
Total Organic Carbon	2.6
Total Dissolved Solids	252
Total Alkalinity ($CaCO_3$)	176
Bicarbonates (HCO_3)	215
Carbonates (CO_3)	0
Hydroxides (OH)	0
Chloride	31
Nitrate Nitrogen	0.1
Sulfate	68
Sodium	24.0
Potassium	1.5
Calcium	84
Magnesium	12.0
Iron	<0.01
Manganese	2.02
Aluminum	0.1
Silica (SiO2)	14
Fluoride	0.6

NF designates analysis on non-fixed samples if primary analysis is performed on fixed samples.

* designates analytical results reported to one significant figure due to the high background interferences present.

All results are reported as mg/liter.

J. C. Wolfhill

R. G. Edwards, Ph. D.
Vice President

Invoice Number 12281

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Sample

W-5112 19 Groundwater samples picked up by Martel Laboratory Services on Febraury 6, 1984.

Geraghty & Miller, Inc.
844 West Street
Annapolis, Maryland 21401
Attn: Mr. Cleason Smith

February 28, 1984

Analysis	Preservative	MW-1	MW-2	MW-3	MW-4
pH	neat	6.1	10.3	6.2	6.9
Total Organic Carbon	H2SO4	0.7	1600	2.0	4.7
Total Organic Carbon	NaOH	1.1	520	1.7	4.7
Total Dissolved Solids	neat	226	6890	514	426
Total Alkalinity ($CaCO_3$)	neat	53	4140	189	263
Bicarbonates (HCO_3)		64	1220	230	321
Carbonates (CO_3)		0	1880	0	0
Hydroxides (OH)		0	0	0	0
Chloride	neat	38	1200	32	34
Nitrate Nitrogen	neat	0.1	2.8	0.1	2.4
Sulfate	neat	31	329	169	69
Sodium	HNO3	14.9	2290	41.5	39.2
Potassium	HNO3	1.2	3.4	1.7	3.1
Calcium	HNO3	32.8	20.7	103	75
Magnesium	HNO3	3.6	2.2	15.4	14.4
Iron	HNO3	0.01	58	0.83	<0.01
Manganese	HNO3	0.54	2.46	3.55	4.09
Aluminum	HNO3	0.1	6.0	0.1	0.1
Aluminum	NaOH	0.1	2.3	0.1	0.1
Silica	HNO3	24	100	19	11
Silica	NaOH	19	35	12	8
Fluoride	neat	0.1	420	0.3	1.5

Analysis	Preservative	MW-5	MW-7	MW-8	MW-9
pH	neat	9.6	5.9	9.5	7.7
Total Organic Carbon	H2SO4	2300	1.4	4.5	1.7
Total Organic Carbon	NaOH	1800	1.4	6.4	2.1
Total Dissolved Solids	neat	3030	398	628	483
Total Alkalinity ($CaCO_3$)	neat	1410	65	316	259
Bicarbonates (HCO_3)		1010	79	234	316
Carbonates (CO_3)		348	0	74	0
Hydroxides (OH)		0	0	0	0
Chloride	neat	750	125	37	25
Nitrate Nitrogen	neat	0.8	<0.1	<0.1	1.3
Sulfate	neat	565	55	80	80
Sodium	HNO3	1030	49.2	199	106
Potassium	HNO3	4.7	2.2	1.2	2.0
Calcium	HNO3	9.9	44.2	2.1	51
Magnesium	HNO3	3.6	11.3	1.1	5.7
Iron	HNO3	18.0	9.0	0.23	0.10
Manganese	HNO3	1.39	4.72	0.04	0.02
Aluminum	HNO3	9.5	0.1	0.5	0.2
Aluminum	NaOH	6.8	<0.1	0.5	0.1
Silica	HNO3	63	42	12	15
Silica	NaOH	32	38	12	17
Fluoride	neat	120	0.1	18	6.6

Analysis	Preservative	MW-10	MW-11	MW-12	MW-13
pH	neat	7.6	9.6	7.5	7.5
Total Organic Carbon	H2SO4	3.4	17	1.4	1.8
Total Organic Carbon	NaOH	3.6	16	0.9	1.4
Total Dissolved Solids	neat	593	778	305	352
Total Alkalinity ($CaCO_3$)	neat	224	387	141	137
Bicarbonates (HCO_3)		273	323	172	167
Carbonates (CO_3)		0	73	0	0
Hydroxides (OH)		0	0	0	0
Chloride	neat	47	45	29	38
Nitrate Nitrogen	neat	3.3	<0.1	0.6	0.4
Sulfate	neat	183	101	85	113
Sodium	HNO3	106	232	23.8	31.2
Potassium	HNO3	3.2	4.1	2.5	2.4
Calcium	HNO3	78	3.3	66	68
Magnesium	HNO3	7.6	2.9	11.6	11.1
Iron	HNO3	0.30	7.9	0.02	0.14
Manganese	HNO3	0.26	0.37	0.71	2.25
Aluminum	HNO3	0.2	20	0.2	0.2
Aluminum	NaOH	<0.1	8.0	0.1	0.1
Silica	HNO3	20	44	14	13
Silica	NaOH	18	37	12	10
Fluoride	neat	5.5	27	2.0	1.9

Analysis	Preser-vative	MW-14	MW-15	MW-16	MW-17
pH	neat	8.1	6.9	9.7	7.6
Total Organic Carbon	H2SO4	1.7	1.4	190	1.6
Total Organic Carbon	NaOH	1.3	1.1	170	1.3
Total Dissolved Solids	neat	327	382	1880	371
Total Alkalinity ($CaCO_3$)	neat	152	188	1010	228
Bicarbonates (HCO_3)		185	229	732	278
Carbonates (CO_3)		0	0	246	0
Hydroxides (OH)		0	0	0	0
Chloride	neat	31	34	367	29
Nitrate Nitrogen	neat	1.2	2.7	5.5	0.5
Sulfate	neat	94	80	161	69
Sodium	HNO3	52	29.4	570	52
Potassium	HNO3	2.5	1.3	3.9	1.7
Calcium	HNO3	54	94	22.1	69
Magnesium	HNO3	8.8	5.1	6.8	11.1
Iron	HNO3	0.06	0.13	13.9	0.39
Manganese	HNO3	0.16	<0.01	1.41	1.77
Aluminum	HNO3	0.2	0.2	6.7	0.2
Aluminum	NaOH	<0.1	0.1	6.0	<0.1
Silica	HNO3	13	16	58	12
Silica	NaOH	13	15	49	11
Fluoride	neat	3.1	0.1	98	4.4

Analysis	Preser-vative	MW-18	MW-19	MW-20
pH	neat	9.8	7.1	6.6
Total Organic Carbon	H2SO4	170	1.2	2.1
Total Organic Carbon	NaOH	200	0.6	1.9
Total Dissolved Solids	neat	7440	369	335
Total Alkalinity ($CaCO_3$)	neat	5570	243	166
Bicarbonates (HCO_3)		2670	296	203
Carbonates (CO_3)		2028	0	0
Hydroxides (OH)		0	0	0
Chloride	neat	80	29	33
Nitrate Nitrogen	neat	0.3	0.1	<0.1
Sulfate	neat	665	67	75
Sodium	HNO3	2750	20.2	22.9
Potassium	HNO3	13.0	6.9	1.7
Calcium	HNO3	8.2	97	76
Magnesium	HNO3	4.7	10.5	12.1
Iron	HNO3	61	0.05	0.04
Manganese	HNO3	0.50	0.26	1.99
Aluminum	HNO3	15	0.2	0.2
Aluminum	NaOH	6.6	<0.1	<0.1
Silica	HNO3	110	13	14
Silica	NaOH	30	12	11
Fluoride	neat	350	0.5	0.5

All results reported as mg/liter on samples as received.

Preservatives are indicated. Carbonates, Bicarbonates, and Hydroxides are calculated from the two step alkalinity titration. All procedures are either from Standard Methods for the Examination of Water and Wastewater, 15th edition, or U.S. Environmental Protection Agency Methods of Chemical Analysis of Water and Wastes, 1979.

R G Edwards

R. G. Edwards, Ph. D.
Vice President

CYANIDE AMENABLE TO CHLORINATION

ANALYTICAL RESULTS FROM MOST RECENT SAMPLING EVENTS
FROM MONITORING WELLS INSTALLED FOR THE PURPOSE OF MEASURING
POTENTIAL IMPACTS FROM THE FDPS

Date Sampled	Monitoring Well	Cyanide Amenable to Chlorination (mg/L)
2/23/90	MW-14	0.0676
2/22/90	MW-17	<0.005
6/30/88	MW-33S	<0.01
6/30/88	MW-33D	<0.01
2/23/90	MW-34S	0.026
2/23/90	MW-34S Dup.	0.0416
7/5/88	MW-34D	<0.01
6/28/88	MW-39S	0.10
6/28/88	MW-39D	0.03
6/27/88	MW-40S	<0.01
6/27/88	MW-40D	<0.01
2/23/90	MW-42S	0.079
6/29/88	MW-42D	<0.01
6/29/88	MW-42D Dup.	<0.01

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF

OCT 12 1993

Mr. John D. Reggi
Ormet Corporation
P.O. Box 176
Hannibal, Ohio 43931

Dear Mr. Reggi:

U.S. EPA has completed its review of Ormet's draft FS Report which U.S.EPA received on April 27, 1993. While U.S. EPA disagrees with many of Ormet's characterizations of facts, U.S. EPA is no longer requiring modification of such, except as provided in the attached addendum.

Ormet has been given the opportunity to make the necessary changes to the Feasibility Study (FS) Report in the past, but has failed to satisfactorily perform this task. Many of the comments that were provided to Ormet in a letter dated October 3, 1991, disapproving a draft FS, had to be repeated in another letter dated January 3, 1993, disapproving a subsequent, revised draft FS. In that letter, the Agencies (the U.S. EPA and the OhioEPA) specified that "[w]hile the Agencies want to reemphasize their previous offer to help Ormet submit an acceptable document, U.S. EPA and OEPA reserve their rights to complete the RI/FS under the terms of the Order if the next submittal is not a Final FS Report. A Final FS Report must incorporate all of the enclosed comments, including the Appendix F comments sent to you by our December 11, 1992 letter." (Emphasis in original) A Final, approvable FS Report was not submitted by Ormet. Again, Ormet failed to satisfactorily incorporate the Agencies' comments. The constant refusal to do so by Ormet has caused significant delay in the cleanup of this site.

Consequently, U.S. EPA has explicitly set forth the necessary modifications to the April 1993 FS Report in the attached addendum. Should Ormet accept these modifications, Ormet can simply submit a clean copy of the April 1993 FS Report with this addendum attached to it as an introductory section, and U.S. EPA will deem the FS a final document. Should Ormet reject these modifications, however, the FS will be deemed disapproved as of the date upon which the revised document is due under the Administrative Order by Consent (CO), or as soon as Ormet notifies U.S. EPA of its rejection of the proposed modifications, whichever occurs first. U.S. EPA will then proceed to complete an FS Report, as was anticipated under Section XXIV of the CO.

This is the last opportunity for Ormet to submit an approvable, Final FS Report. U.S.EPA hopes that Ormet will accept these modifications and submit a Final FS, comprised of the enclosed addendum supplementing a clean copy of the April 1993 FS Report.

No extension to the deadline upon which a Final FS Report is due, as set forth in Section X of the CO, will be granted by the Agencies because all of the necessary modifications have already been made for Ormet. All that is necessary for Ormet to do is to remove the red-lined format and delete the strike-out provisions of the FS. The CO provides plenty of time for Ormet to complete such minor tasks.

U.S. EPA is looking forward to your response and is quite optimistic that you will find the attached modifications acceptable.

Sincerely,

Rhonda E. McBride

Rhonda E. McBride
Remedial Project Manager
U.S. EPA

CC: Rick Wiedman, Eckert, Seamans & Mellot Attorneys at Law
Gene Bollo, Ormet Corporation
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December 1, 1993

Ms. Rhonda E. McBride
Ormet Corporation RPM
Hazardous Waste Enforcement Branch (5HS-11)
Waste Management Division
U.S. Environmental Protection Agency
Region V
230 S. Dearborn Street
Chicago, Ill. 60604

and

Ms. Kay Gilmore Gossett
Ormet Site Coordinator
Ohio Environmental Protection Agency, SEDO
2195 Front Street
Logan, Ohio 43138

RE: Ormet Corporation -- Administrative Order
By Consent Re: Remedial Investigation And
Feasibility Study; U.S. EPA Docket No. V-W-87-C-013

Dear Ms. McBride and Ms. Gossett:

Enclosed is the Feasibility Study ("FS") Report for the Ormet Corporation ("Ormet") Superfund Site (the "Site"). At your direction we are providing 10 copies of the Report to the United States Environmental Protection Agency ("EPA") and 3 copies to the Ohio Environmental Protection Agency ("Ohio EPA") (sometimes referred to collectively as the "Agencies") and we have included EPA's Addendum (the "Addendum") at the front of the Report.

The FS Report as originally drafted by Ormet met or exceeded the requirements of the Administrative Order on Consent between Ormet and the Agencies (the "CO"). That draft was submitted to the Agencies for review in strict accordance with an agreed to expedited schedule in January, 1991. Since that submission, at the direction of the Agencies, numerous revisions have been incorporated into the document. Most recently Ormet was directed to include the above referenced Addendum. Ormet does not agree with the validity or utility of many of the changes which have been forced into the document over the last several years. However, subject to the express disclaimer included on the face sheet of the Addendum, as discussed with you and agreed to at our meeting in Chicago on November 1, 1993, Ormet has completed the FS Report as directed. Ormet specifically reserves and does not waive any rights including, but not limited to, the right to object to and comment upon any aspect of the Proposed Plan which may refer to or rely upon the FS Report.

Based upon the Agencies' letters dated October 12, 1993 and our November 1, 1993 discussions in Chicago, Ormet is submitting the FS Report including the Addendum with the understanding that the FS Report is complete and will be accepted by the Agencies in satisfaction of the requirements of the CO. Upon acceptance, we will distribute signature pages for execution on behalf of Ormet and the Agencies. Several of the changes as well as some of the pejorative remarks contained in the Agencies' October 12, 1993 letters warrant a written response and are addressed below.

<u>General Comments</u>

Throughout the FS process, Ormet cooperated with the Agencies and diligently prepared an FS Report which was technically and factually sound as originally submitted. After addressing a voluminous and often inconsistent series of comments over the last three years, the FS Report now consists of thousands of pages of text and appendices and contains analyses of potential remedial measures for the conditions at the Site which far exceed the level of detail found in many FS reports approved by the Agencies for other Superfund sites. Ormet takes exception to the Agencies' mischaracterization of the FS Report as deficient and takes particular exception to any implication that Ormet is in any way responsible for a delay in the determination of remediation, if any, for this Site.

As noted above, Ormet agreed to an expedited schedule in January, 1991 as an accommodation to the Agencies. Despite a revision process which can at best be characterized as cumbersome, Ormet met its deadlines. The delays in the process, if any, are rooted in the Agencies' failure to coordinate and review submissions on a timely basis, the piecemeal approach imposed by the Agencies in the preparation of the FS Report and completion of the RI Report and the inconsistent and disjointed comments to which Ormet had to respond. Often Ormet was directed to remove language only to be criticized thereafter for not addressing the very issue and to find almost identical language ultimately included in the Addendum. Specific examples include the relocation of Outfall 004, the failure to identify at any time (until November 10, 1993) the purported deficiency in cap design under OAC 3745-27-11 and the inclusion of <u>new</u> ARARs as recently as October 12, 1993. In addition, the process has been delayed by the failure of EPA's contractor to properly and competently conduct the Baseline Risk Assessment ("BRA"), which had to be corrected twice at significant expense to Ormet. As the BRA ultimately confirmed, the Ormet Site poses no current risk of practical significance. Ormet is an operating industrial facility situated in a sparsely populated, heavily industrialized area. However, rather than acknowledge this reality, the process has been further delayed by the Agencies' consistent failure to address the Site in context which in some cases involved blatant manipulation and preselection of inappropriate remedies contrary to CERCLA, the NCP and the approach taken by the Agencies with respect to other sites. While Ormet certainly agrees that the RI/FS process has been unnecessarily complicated, lengthy and costly, to suggest that Ormet bears responsibility for any material delay in this process is counter productive and contradicts the well documented history of the program administration of this Site. Indeed, it is worth noting that after spending over $2.5 million on the RI/FS, the practical results are no different than disclosed in the groundwater report Ormet submitted to Ohio EPA in 1984. As the Agencies are aware, Ormet, with some difficulty, sought and obtained the concurrence of both Agencies to enable it to move forward with the groundwater treatment facility which is currently under construction.

Specific Comments

Groundwater

The elimination of alternate concentration limits ("ACLs") from future consideration based upon information currently available is inappropriate and technically unsound because there is insufficient data available to determine whether it will be practicable to attain MCLs in the groundwater. A technical evaluation of the potential for aquifer restoration is contained in Appendix K and although the conclusion reached is that MCLs may be achievable in the future, the feasibility of aquifer restoration, as recognized by EPA in a number of published reports, is very difficult to predict. Section 121(d) of CERCLA, 42 U.S.C. §9621(d) and 40 C.F.R. § 300.430(e)(2)(i)(F), provide that the application of an ACL should be considered at a time when there is enough information to determine whether it is practicable to attain MCLs. As evidenced by the absence of a technical justification in the Addendum, there is no basis for concluding at this time that MCLs can be practicably attained in the aquifer beneath the Site and, therefore, it should be recognized that the application of ACLs at some time in the future may be appropriate.

With regard to the discussion of the risk associated with groundwater, the text of the FS Report as submitted by Ormet accurately paraphrases the BRA which concluded that no existing populations are exposed to the groundwater at the Site. Since no existing population is currently exposed to groundwater, there is no current risk. EPA's conclusion that there is a current risk associated with groundwater because the BRA concluded that hypothetical future residents could drill drinking water wells and thereby be exposed to contaminated groundwater, is a gross distortion of reality. The statement in the FS Report that there is no current risk associated with groundwater is accurate.[1]

Flood Control Measures

The Addendum and Ohio EPA's letter erroneously indicate that the FS Report is deficient because it does not contain a remedial measure which satisfies the requirements of OAC 3745-54-18 which provides that containment measures associated with hazardous waste landfills located in the 100 year floodplain should be constructed to prevent washout.[2] In particular the failure to establish the presence of the natural levee along the entire face of the CMSD and the failure to provide for the protection of the seep collection system from the effects of 100 year flood conditions were inappropriately identified as deficiencies in the FS Report.

The incorporation of the natural levee into remedial measures for the CMSD is based upon data collected during the RI which appear to indicate that there is a natural levee along the face of the CMSD. The full extent of this natural levee has not been evaluated at this point because such an evaluation is beyond the scope of the RI/FS process. If a remedy is selected for the CMSD which utilizes the natural levee, additional data will likely have to be developed to evaluate precisely how the natural levee would be incorporated into the containment measure. An engineering evaluation of this nature would be performed during the remedial design phase.

Moreover, the presence of the natural levee is not critical to the technical sufficiency of the containment measures conceptualized in the FS Report. Should it be determined during the remedial design phase that the natural levee is not adequate for the

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[1]The hypothetical scenario contravenes existing guidance and the realities of the Site, i.e., Ormet is an operating industrial facility located in sparsely populated, but heavily industrialized area. Even if this scenario were considered reasonable (and it is not), it cannot form the basis for concluding that there is a current unacceptable risk associated with groundwater.

[2]The requirements of OAC 3745-54-18 are siting criteria which apply on a prospective basis and do not apply retroactively to facilities such as Ormet's construction materials scrap dump ("CMSD") which was located in the floodplain prior to the promulgation of this regulation. Since the jurisdictional prerequisites to the applicability of this regulation are not satisfied, contrary to the statement in Ohio EPA's October 12, 1993 letter this requirement cannot be and is not "applicable." Moreover, any administrative determination regarding applicability would be improper since all ARARs must be identified solely as potential throughout the FS process.

intended purpose, the function to be served by the levee will be addressed through the use of other engineering measures.

Similarly, the seep collection system discussed in the FS Report obviously has not been designed at this point and the precise nature of the seep collection system is not critical to the conceptual discussion of this remedial measure in the FS Report. There are a variety of ways to design seep collection systems and if a remedy is selected which incorporates a seep collection system, protection of that system will be addressed during the remedial design phase.

The Addendum also contends that the containment measures described for the CMSD do not provide for adequate "freeboard, which may be necessary because of wave action in the Ohio River . . . ." The evaluation of freeboard is also an issue properly suited for consideration during the remedial design phase. Nonetheless, a review of the FS Report clearly discloses that freeboard was addressed. Figure 5.9 shows that revetments would be placed above the 100 year flood level and the amount of material needed for freeboard was factored into the volume calculations for these materials contained in the FS Report. The precise amount of freeboard which might be necessary would be evaluated during the remedial design phase. Moreover, though not applicable, these measures are fully consistent with OAC 3745-54-18 and the parallel federal provision from which it is derived.

Vegetative Soil Covers

The Addendum's discussion of routine maintenance preventing plants and burrowing animals from penetrating the soil cover containment measure discussed in the FS Report is redundant. This discussion and the comparison of the soil cover containment measure to the solid waste closure standards contained in OAC 3745-27-11(G) add nothing to the technical sufficiency of the FS Report and provide no discernible benefit to the reader in terms of clarity or ease of understanding.

Comparison of Capping Measures

The Addendum's comparison of single barrier clay caps to single barrier caps utilizing a synthetic membrane appears to be little more than a misleading manipulation of the FS to improperly exclude from consideration single barrier caps utilizing a synthetic membrane as the impermeable layer. The text of the FS Report provides a balanced discussion of the pros and cons of single barrier caps utilizing synthetic membranes as compared to clay for the impermeable layer.

In addition, the suggestion that the single barrier cap depicted in the FS Report is deficient because it does not incorporate a 2' thick layer of common borrow to protect the impermeable layer from root penetration and freeze and thaw is inappropriate. OAC 3745-27-11 does not require a 2' thick layer of common borrow. To the contrary, OAC 3745-27-11(G) provides, in pertinent part, that:

> A vegetative layer consisting of soil and vegetation, placed on top of the granular drainage layer. The soil shall be of sufficient thickness and fertility to support its vegetation and to protect the soil barrier layer for damage due to root penetration and frost.

The conceptual drawing included in the FS Report depicts a 15" thick vegetated soil layer which meets or exceeds the performance criteria specified in OAC 3745-27-11(G). The FS Report is intended to provide in conceptual form the types of remedial measures which are suitable for a given site. Moreover, it is worth noting that throughout the three years it has taken to complete the FS Report it was not until the November 10, 1993 revision to the Addendum that Ormet was informed for the first time that the thickness of the soil layer formed the basis for the Agencies' comment.

In order to avoid controversy, the discussion of the long term reliability of the various capping alternatives incorporated into sitewide remedial alternatives, i.e., that both single and dual barrier caps are considered to be reliable over the long term, was intentionally drafted to mirror the discussion contained in an FS Report recently approved by the Agencies for a site located in southeastern Ohio.

Appendix K

The discussion in the Addendum regarding the aquifer restoration analysis contained in Appendix K to the FS Report is incorrect and misleading. The assumptions presented in Appendix K are based on site-specific data and constitute realistic assumptions. The estimate of the pumping rate of the hypothetical wells is based on a calculation of the volume of groundwater flowing through the aquifer along the downgradient boundary of the former spent potliner storage area (the "FSPSA") and accepted guidelines. Moreover, regardless of the number of wells utilized to extract groundwater, the total pumping rate required to capture the groundwater passing through that section of the aquifer will be no different than the pumping rates utilized in the analysis contained in Appendix K.

Similarly, projected removal rates for the cyanide (which is predominantly an iron-complexed non-toxic compound) and the level at which the cyanide concentrations in the pumping wells would level off is based on actual data. Although wells placed closer to the source area would be expected to extract groundwater containing higher concentrations of contaminants, the total mass removal rate, which is the primary measure of the effectiveness of groundwater remediation would be the same under either the existing pumping scenario or the hypothetical scenario discussed in Appendix K.

The specific modifications contained in the Addendum also are incorrect and are addressed below:

1. The statement regarding the effect of containment measures at the FSPSA and the impact on aquifer restoration time periods is redundant. The FS Report as drafted states that treatment and/or capping of the FSPSA would be expected to decrease the restoration time period by some amount of time. If the statement in the Addendum is intended to imply that the highest and best use of that portion of the Ohio River Valley aquifer beneath the Ormet plant site is anything other than industrial, it is a gross mischaracterization. There is no reasonable potential for any use other than industrial for this site throughout the foreseeable future.

2. The location of extraction wells under GW-3 has already been determined as these wells are currently in place and operating efficiently.

3. It is estimated that groundwater alternatives GW-5 and GW-3 would result in restoration of the aquifer in 36 to 38 years, respectively. A combination of GW-3 and GW-5 would not result in a shorter restoration period. The statement that a combination of GW-3 and GW-5 would result in achievement of MCLs in a slightly shorter amount of time is without scientific basis and at best is misleading since the distinction between 36 and 38 years in this context is meaningless.

4. There is no basis for contradicting the statement contained in the FS Report that a treatability study to determine whether NPDES permit limits can be achieved could be completed more quickly than the three years estimated by Ormet. The three year time estimation for the treatability studies is based upon Ormet's extensive experience with the treatability studies associated with the development and design of the groundwater treatment system currently under construction.

Appendix F

Institutional Controls

The statements in the Addendum and Ohio EPA's letter that institutional controls have been utilized improperly in the FS Report are incorrect. At no time have institutional controls been utilized as stand-alone measures in lieu of active remedial response measures and statements in the Addendum and correspondence to the contrary are incorrect and misleading. Each sitewide alternative developed in the FS Report, except the no action alternative required by the NCP, includes active remediation and institutional controls. Ormet is an operating industrial facility located in a rural but heavily industrialized area. Accordingly, the Ormet site is very well suited for the utilization of institutional controls to enhance the effectiveness of any active remedial measure.

At the last project review meeting it was agreed that Ormet would develop remedial action goals in accordance with the Risk Assessment Guidance for Superfund, Part B, and that Ormet would include cleanup goals for both residential and industrial scenarios. In a letter dated March 4, 1993 and signed by representatives of Ohio EPA and EPA, the Agencies stated that: "[i]f Ormet wishes, they may present goals for the Industrial Use Scenario in addition to the Residential Use Scenario remedial action goals." See Letter from Rhonda McBride and Richard Stewart to John Reggi dated March 4, 1993. Appendix F to the FS Report presents cleanup goals based upon both a residential use scenario (See Tables F-7 and F-8) and an industrial use scenario (See Table F-12). This was entirely consistent with the agreement reached at the project review meeting and the suggestion that the FS Report was deficient because it contains both scenarios is inappropriate.

Appendix F contains health-based remediation goals for each media where there is a reasonable potential for exposure. Institutional controls are a component of each sitewide remedial alternative, except the no-action alternative, and under each sitewide alternative institutional controls will effectively block certain exposure pathways. For example, under sitewide alternatives 3 and 4, institutional controls such as a deed restrictions and fencing would be utilized in conjunction with different capping scenarios. The institutional controls merely supplement the active remedial measure of capping and yet the institutional controls alone will eliminate the potential for future residential use of that area. Therefore, because there is no potential for future residential use and no exposure pathway for residential use of groundwater, no remediation goal is warranted for groundwater. This approach is consistent with the approach taken in Attachment 1 to the Addendum where EPA states that:

> When remediation will result in eliminating an exposure (i.e., as by capping the material) it is not necessary to calculate [remediation goals] since the exposure pathway assumed in the risk assessment would be incomplete.

Since Appendix F contains remediation goals for each media for which there is the potential for exposure, it is inappropriate to characterize the FS Report as deficient for failing to develop residential use cleanup goals.

PCB-Contaminated Sediments

Ormet does not disagree with the discussion of ARARs and TBCs in connection with PCB-contaminated sediments contained in the Addendum. Indeed, this discussion reflects the sum and substance of Ormet's annotations to the last revisions to the FS Report where Ormet disagreed with the Agencies utilization of TBC material as a basis for establishing required cleanup levels.

Remedial Action Goals/Levels

The preliminary remediation goals ("PRGs") for PCBs in sediment contained in Attachment I to the Addendum are inconsistent with accepted guidance and studies published by EPA and do not recognize the enormous uncertainties associated with risk calculations for the dermal exposure pathways. Current EPA guidance for the calculation of PRGs does not even consider the dermal exposure pathway for the calculation of PRGs for soil, let alone sediment, because there are too many uncertainties associated with the calculation of dermal soil exposures. Dermal exposure calculations for sediment are even more uncertain because of the added confounding factor of water reducing the adherence of particulate matter to skin. Therefore, consideration of the dermal exposure factor in calculating PRGs for PCBs in sediments has no foundation and is inappropriate.

In addition, it appears that EPA utilized a soil adherence factor in its calculations for the PRGs for PCBs in sediment of 2 mg/cm^2-day even though the default value specified by current EPA guidance is .2 to 1 mg/cm^2-day. There is no actual site-specific data which would support the use of a higher adherence factor. EPA also appears to have used an incorrect dermal absorption factor for PCBs. Accepted Agency guidance, including the EPA's PCB Spill Cleanup Policy and the EPA report "Development of Advisory Levels for Polychlorinated Biphenyls (PCBs) Cleanup" (EPA, 1986)", both specify a dermal absorption efficiency of 5% whereas EPA utilized a dermal absorption factor of 10%. Proper application of currently accepted guidance and good science yield PRGs for PCBs of 1.1 E

+ 01 and 4.3 E + 00 for the hypothetical trespasser and resident, respectively. (These are the PRGs contained in the revised Addendum provided by EPA to Ormet by letter dated November 10, 1993). There is no justification for this arbitrary departure from established policy and accepted scientific principles.

Remedial Measures SED-6 and SED-8

The FS Report contains a discussion of the effectiveness of the installation of sheet piling and concrete revetments over contaminated sediments in the same manner as that contained in the Addendum. Therefore, the Addendum is redundant.

In addition, Attachment 1 to the Addendum states that the remediation goal for sediments must utilize the human health goal because it is lower than the ecological goal and only the lower goal is protective of both human health and ecological receptors. This statement is incorrect because the only remedial measures which do not include complete dredging incorporate containment measures which will eliminate any potential human exposure. Attachment 1 to the Addendum recognizes that elimination of the exposure pathway eliminates the need for a human health remediation goal. Therefore, there is no basis for establishing remediation goals at unreasonably low levels which are protective of human health since there is no exposure pathway.

Assembly and Screening of Remedial Measures

The discussion regarding plume mobility and migration is misleading. This discussion implies that the current pumping scenario will cause the contamination of a significant portion of the Ohio River Valley aquifer. The affected 2,700 foot segment referenced is a very small portion of the overall aquifer (less than 10%) and the current pumping scenario will continue to effectively contain that segment.

There is no basis for modifying the discussion in the FS Report regarding the effectiveness of the soil cover remedial measures. The soil covers will eliminate the direct exposure and airborne exposure pathway immediately upon implementation and there is no current potential exposure to groundwater. The placement of soil covers over the FSPSA would allow for continued flushing of the area and the groundwater extraction system would continue to treat and address the contaminated groundwater. Because all potential exposure pathways are eliminated this discussion in the Addendum is unnecessary.

Similarly, the discussion regarding the relocation of the 004 outfall is redundant. Section 4.3.7 of the FS Report clearly provides that Outfall 004 will be rerouted and that the specific location of Outfall 004 will be determined during the remedial design phase.

Development of Site-Wide Alternatives

The discussion regarding the purpose of new interceptor wells is redundant as a similar discussion is contained in both Appendix K and the text of the FS Report.

Detailed Analysis of Site-Wide Alternatives

The FS Report states repeatedly that all waste, including sludge from the groundwater treatment system, will be characterized appropriately and handled in accordance with all applicable requirements. The Addendum improperly predetermines that the character of the sludge generated by the groundwater treatment system will be a hazardous waste "because it will still contain cyanide" and because "[t]he sludge will be so similar to that of K088 listed waste . . ." (Comparative Analysis Section of Addendum). To the contrary, the available data indicates that the material will not be similar to KO88. Certainly, at this time, there is no basis for determining what the characteristics of the sludge will be and it is entirely inappropriate to predetermine that this material will be considered a hazardous waste.

The statement that interceptor wells placed closer to the FSPSA will "reduce the toxicity of contaminant concentrations . . ." is not accurate. Interceptor wells placed closer to the FSPSA would be expected to extract a smaller volume of groundwater with higher concentrations of contaminants, although the total mass removed by interceptor wells placed closer to the FSPSA would be virtually the same as the total mass removed by the extraction system presently in operation. In addition, although interceptor wells placed closer to the FSPSA would restrict the plume to a smaller area, it is expected that it would be more difficult to achieve and maintain containment under such a pumping scenario.

Comparative Analysis of Alternatives

The comparative analysis of sitewide alternatives and the inclusion of this comparative analysis in the Addendum is inappropriate. No technical basis for the scoring of specific remedial measures is provided and the evaluation of the various containment measures appears to contradict the evaluation of similar measures at other Superfund sites. In addition, the cost effectiveness evaluation required by CERCLA and the NCP which require that cost be considered in selecting from remedial options that are adequately protective was not performed properly.

With regard to specific points discussed in the Comparative Analysis:

1. The statement that interceptor wells placed closer to the FSPSA will achieve MCLs in a shorter period of time is misleading since it is

estimated that interceptor wells placed closer to the FSPSA would be projected to achieve MCLs in approximately 36 years whereas it is projected that the existing extraction system will achieve MCLs in approximately 38 years. The text of the FS Report states this clearly.

2. The management of sludge from the groundwater treatment system is discussed above.

3. Single barrier and dual barrier caps are both very effective over the long term; however, dual barrier caps are more than twice as expensive as single barrier caps. Therefore, single barrier caps are much more cost effective and the statement in the Addendum to the contrary is not correct.

4. The long-term reliability analysis selectively mischaracterizes the nature of various alternatives, the conclusions regarding long-term reliability are unfounded, and the distinctions drawn between sitewide alternatives are arbitrary. For example, there is no basis for concluding that sitewide alternative 3 is any less reliable than sitewide alternatives 4 through 10 which are characterized as relying more on treatment and/or removal and more reliable over the long-term.

5. The conclusions regarding the implementability of various containment measures over the former disposal ponds are unfounded. The FS Report concludes that single barrier caps utilizing synthetic membranes as the impermeable barrier could be installed over the former disposal ponds without the need to stabilize the pond solids. No technical support is provided for the unfounded assertion that engineering difficulties may be experienced with the settlement of unstable material under sitewide alternatives 3, 5, 8 and 10.

Conclusion

There is nothing in the well documented history of the program administration of this Site to justify the mischaracterization of Ormet's performance in the Agencies' letters of October 12, 1993 and the Addendum. We disagree with the need for the Addendum, which in many instances is redundant, inaccurate and neither reflects good science nor accepted Agency guidance. Ormet has included the Addendum in the FS Report subject to the reservation of all rights and with the understanding that the Agencies will accept the documents as complete for purposes of the CO. Upon confirmation that the document is accepted we will distribute signature pages for execution.

Very truly yours,

John Reggi

John D. Reggi, Manager
Corporate Environmental Services

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To John Reggi	From Kay Llewett
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Voinovich
Governor

October 12, 1993

RE: **MONROE COUNTY**
ORMET CORPORATION
 # 456-0613
DERR CORRESPONDENCE

CERTIFIED #P 391 866 372

Mr. John Reggi
Ormet Project Coordinator
Ormet Corporation
P.O. Box 176
Hannibal, OH 43931

Dear Mr. Reggi:

Ohio EPA has reviewed Ormet Corporation's (Ormet) final submittal of the Feasibility Study Report (FS Report), April 1993, and regrettably cannot approve the document. Section IX, Paragraph 1, of the Administrative Order by Consent (Consent Order) requires that all work under the Consent Order be done "in accordance with the NCP, the RI Guidance, the FS Guidance, and additional guidance documents provided by U.S. EPA which are not inconsistent with the NCP, and the requirements of this Consent Order, including the standards, specifications and schedules contained in the RI Work Plans and the FS Work Plan." Unfortunately, Ormet's FS Report fails to comply with this requirement of the Consent Order in several respects, the most important of which are discussed below.

Ormet has failed to provide, within their second submittal of the draft Feasibility Study Report, an alternative or component of an alternative which demonstrates compliance with Ohio's Applicable or Relevant and Appropriate Requirements (ARARs), or in the alternative, provides justification for waiving the State's ARARs. According to U.S. EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final (OSWER #9355.3-01, October 1988) and 40 CFR Part 300.430 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the Feasibility Study (FS), along with the detailed analysis of alternatives within the FS, should be conducted to provide decision-makers with sufficient information to compare alternatives with respect to the nine evaluation criteria and to select an appropriate remedy. One of these nine criteria which must be met by the selected alternative, and thus supported by the FS, is the attainment of ARARs. Specifically, 40 CFR Part 300.430 (e)(9)(iii)(B) provides that the alternatives "shall be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws or provide grounds for invoking one of the waivers under paragraph (f)(1)(ii)(C) of this section". Also, section 6.2.3.2 of U.S. EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final,(OSWER # 9355.3-01, October 1988) provides that in the FS Report, the detailed analysis of alternatives should "describe how the alternative meets these requirements (ARARs). When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA (see section 1.2.11) should be discussed."

Ormet's revised FS Report does not demonstrate that any alternative, or alternative component, adequately satisfies the requirements of Ohio Administrative Code (OAC) 3745-54-18 (B). OAC 3745-54-18 (B) requires that a facility located in a one-hundred-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a one-hundred-year flood. This ARAR is applicable to the Construction Materials Scrap Dump (CMSD) which contains wastes within the 100 year floodplain.

Ormet's alternative component for the CMSD includes the use of rip-rap along the cap face above an existing natural flood levee. The maximum height of this levee, as presented in Figure 5-4 of the revised FS Report (April 1993), was shown to be below the 100 year flood elevation. In comments dated January 7, 1993 on Ormet's initial draft FS Report (submitted in parts- December 1991 through June 1992), the Agencies had informed Ormet that OAC 3745-54-18 (B) would be applicable to alternatives for the CMSD. The Agencies further explained to Ormet by telephone conference on February 24, 1993 and in the project review meeting summary of March 4, 1993 that Ormet's proposed alternatives do not provide a level of flood protection for the CMSD which would comply with this ARAR.

Additionally, Ormet's proposed alternatives offer no flood protection for the CMSD seep collection trenches and sumps which will contain contaminated leachate also within the 100-year floodplain. The Agencies stressed in the March 4, 1993 project review meeting summary that a structure designed <u>specifically</u> for the purpose of flood protection would be necessary to prevent washout of CMSD wastes and seep collection trenches by flood waters. However, Ormet has failed to provide such a design component in their April 1993 revised submittal of the <u>Feasibility Study Report</u>.

The April 1993 revised FS Report submittal, also, does not provide an alternative, or alternative component, which can be determined to satisfactorily meet the requirements within OAC 3745-27-11 (G) for the design of a solid waste landfill cap. The conceptual design drawings for the capping of the Former Disposal Ponds (FDPs) contained within this report do not include cap design components which meet the specifications required by this ARAR.

In addition, the revised draft (April 1993) of the Feasibility Study Report-Appendix F develops risk-based clean-up goals yet fails to incorporate these as remedial action goals for the Ormet site. Risk based remedial action goals are required by the Feasibility Study Workplan (November 1990) Section 4.2.2, the NCP 40 CRF Part 300.430 (e)(2)(i)(A)(1) & (2), U.S. EPA guidance and previous Agency comments. In Appendix F of the April 1993 revised Feasibility Study Report, "Remedial Goals for the Ormet Site", Ormet states that "...the calculation of health-based goals for ground water under the limited control scenario is not warranted..." Ormet also states in Appendix F "...calculation of health-based clean-up goals for sediment under a limited control scenario is not warranted..." Ormet determined in the FS Report-Appendix F that risk based clean-up goals were "unwarranted" due to the inclusion of institutional controls within their alternatives. The Agencies, in comments dated December 11, 1992 on Ormet's initial draft Appendix F, specifically required Ormet to delete from Appendix F all discussions regarding the utilization of institutional controls to prohibit the future residential use of contaminated ground water beneath the site and the future residential use of other site media. Ormet's use of institutional controls is inappropriate in this case. Ormet has used institutional controls as a "substitute for active response measures ... as the sole remedy" in contravention of the NCP, 40 CFR Part 300.430 (a)(1)(iii)(D).

Not only eliminate risk ARAR, risk shall be estimated Also based on Indust use Scenario.

Also, within the Agencies' previous comments on Appendix F, dated December 11, 1992, Ormet was required to develop risk based clean-up goals using the residential-use scenario only, since the residential use scenario does not rely solely upon institutional controls to provide protection of human health. Ormet, however, not only ignored this comment but also deleted language in Table 2-1 which it had included in its first submittal of the FS Report regarding residential land use scenarios.

Article X, paragraph (3), of the AOC, requires Ormet to submit a revised document which incorporates U.S. EPA's and OEPA's required modifications. In correspondence to Ormet dated January 7, 1993, the Agencies disapproved Ormet's initial FS submittal (December 1991- June 1992) citing Ormet's failure to adequately address the Agencies' comments on previous sections of the FS submitted by Ormet as a fundamental deficiency. The Agencies also informed Ormet that failure to incorporate all of the Agencies' modifications in Ormet's revision of the FS Report, or to include changes other than those identified by the Agencies, would be construed as a violation of the Order. Ormet's second draft of the Feasibility Study Report (April 1993) has failed to include previous modifications and revisions required by the Agencies.

Therefore, by this correspondence, Ormet is hereby notified that the Ohio EPA disapproves the second submittal of the Feasibility Study Report (April 1993) and maintains that Ormet is in violation of the Administrative Order by Consent. Under the Consent Order, the Ohio EPA has the right to take over the project and/or enforce the terms of the Consent Order after the Ohio EPA and U.S. EPA have disapproved any document. Because U.S. EPA intends to conditionally approve the second submittal of the Feasibility Study Report (April 1993) with specifications, however, and because the Ohio EPA desires to see this project move forward as soon as possible, the Ohio EPA will not seek to exercise its enforcement rights at this time. Should U.S. EPA eventually disapprove the second submittal, however, the Ohio EPA reserves its right under the Consent Order to take over the project and/or enforce the terms of the Consent Order.

Sincerely,

for

Kay Gilmer Gossett
Site Coordinator
Division of Emergency and Remedial Response

KGG/mr

cc: Jenifer Kwasniewski, DERR, CO
Jeff Hurdley, Legal, CO
Sue Nitecki, DERR, CO

OhioEPA
State of Ohio Environmental Protection Agency

Southeast District Office
2195 Front Street
Logan, Ohio 43138-9031
(614) 385-8501
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George V. Voinovich
Governor

December 8, 1993

RE: **MONROE COUNTY**
ORMET CORPORATION
 # 456-0613
DERR CORRESPONDENCE

John D. Reggi
Ormet Project Coordinator
Ormet Corporation
Route 7
P.O. Box 176
Hannibal, Ohio 43931

Dear Mr. Reggi:

On December 1, 1993 Ohio EPA received the Ormet Final Feasibility Study Report with accompanying correspondence from Ormet which was directed to both U.S. EPA and Ohio EPA. From this December 1, 1993 correspondence, we conclude that Ormet has misunderstood Ohio EPA's position regarding the Final FS as outlined in Ohio EPA's October 12, 1993 letter to Ormet.

As Ohio EPA clearly stated to Ormet in our October 12, 1993 correspondence, "...Ohio EPA disapproves the second submittal of the Feasibility Study Report (April 1993)...". Ohio EPA also stated that it was U.S. EPA's intention to "conditionally approve the second submittal of the Feasibility Study Report (April 1993) with specifications...". Therefore, Ohio EPA wishes to clarify for Ormet that the State does not accept the Ormet Final FS, submitted December 1, 1993, as complete. Ohio EPA did not participate in the development of, or concur with, the U.S. EPA Addendum to the FS report. Ohio EPA will not be a signatory to the Ormet Final Feasibility Study Report as submitted December 1, 1993.

Comments or concerns which Ormet may have specific to Ohio EPA's October 12, 1993 correspondence to Ormet should be addressed directly to this Agency. Upon receipt of the Ormet Corporation's concerns, Ohio EPA will respond promptly. We believe Ormet's concerns regarding the FS and the Addendum can most appropriately be addressed by U.S. EPA.

We hope that this has clarified Ohio EPA's position in this matter. If you have any questions, feel free to contact me.

Sincerely,

Kay Gilmer Gossett

Kay Gilmer Gossett
Site Coordinator
Division of Emergency and Remedial Response

KGG/mr

cc: Rhonda McBride, USEPA, Region V
Jeff Hurdley, Legal, CO
Jenifer Kwasniewski, DERR, CO

GERAGHTY & MILLER, INC.
Environmental Services

Ground Water *Engineering* *Hydrocarbon* *Remediation* *Education*

May 23, 1994

Mr. John Reggi
Ormet Corporation
Route 7
P.O. Box 176
Hannibal, OH 43931

RE: Cyanide Toxicity Fact Sheet

Dear Mr. Reggi:

As requested the attached fact sheet conveys the technical basis behind the lower environmental hazards posed by cyanide complexes. If you have any questions or require additional information please let me know.

Sincerely,
GERAGHTY & MILLER, INC.

Frank A. Jones, Ph.D.
Principal Toxicologist/Associate

cc Mr. Steven Faeth - Eckert Seamans

FREE, SIMPLE AND COMPLEXED CYANIDES

Cyanides are a group of organic and inorganic compounds that contain the CN^- moiety. Cyanides exist in various forms in the environment and are categorized as either free cyanide, simple cyanide, or complex cyanide. Free cyanide refers to the sum of the cyanide ion and molecular HCN. Simple cyanides are compounds (ie., NaCN) that consist of a cyanide ion and a cation. Complex cyanides are compounds in which cyanide is incorporated into a complex or complexes.

Cyanates, which contain the -OCN radical, are formed industrially by oxidation of cyanide salts. Cyanates hydrolyze in water to form ammonia and bicarbonate ion (USEPA, 1979). Cyanates, when compared to cyanide, are relatively nontoxic to humans and animals (USEPA, 1978).

The stability of the complex cyanides vary from the highly stable iron and cobalt cyanides, the intermediate nickel and copper cyanides, and the easily decomposable zinc cyanides (USEPA, 1979). Free cyanide is considered the primary toxic agent. The other forms of cyanide can contribute to the concentration of free cyanide in the environment depending on their stability and environmental conditions.

Hydrogen cyanide is soluble in water and dilute acid (which includes the gastric environment), and will readily hydrolyze to 1 molar equivalent of cyanide (CN^-) and 1 molar equivalent of hydrogen (Hartung, 1982). Simple metal cyanides are insoluble and probably will would be transported as suspended solids or would settle out into sediments. Complex metallocyanides are more soluble, and would be transported in solution (USEPA, 1979).

Changes in the concentration ratio of cyanide to metals will alter the form of cyanide compounds. When metals are prevalent, the simple cyanides are predominant. When cyanide is prevalent, the complex metallocyanides are favored (USEPA, 1979).

In the past, surveys of public water supplies have revealed no cyanide concentrations above drinking water standards. In part, this was ascribed to the volatility of undissociated hydrogen cyanide, which would be the predominant form in all but highly alkaline waters. Also, in part, cyanide ion has a decided tendency to be "fixed" in the form of insoluble or undissociated complexes by trace metals. Cyanide may complex irreversibly with heavy metals in water supplies and thereby be biologically inactivated in terms of toxicity attributable to cyanide (USEPA, 1985).

Cyanide is rapidly absorbed into the body by all routes of exposure (gastrointestinal tract, lungs, and skin). Once absorbed, cyanide is distributed throughout the body via the blood. Cyanide is not bioaccumulated in any tissues, and is instead rapidly detoxified in the liver by the intramitochrondrial enzymes. The enzyme rhodase will convert cyanide to thiocyante , which is eliminated from the body via the urine (USEPA, 1987).

Cyanide is a rapid acting toxicant, that disrupts cellular respiration. Cyanide ions will complex with the metals present in various enzymes, inhibiting the catalytic activity. Hypoxia results when cyanide interupts the electron transfer down the cytochrome chain by inhibiting cytochrome oxidase (Smith, 1980).

Chronic exposure to low levels of simple cyanides has been reported to cause enlargement of the thyroid in humans. Inefficient elimination of the metabolite thiocyanate is reported to be associated with this adverse effect (NIOSH, 1976).

The iron cyanide complexes (i.e., ferricyanide and ferrocyanide) are extremely stable, normally releasing negligible amounts of the toxic cyanide ion (NRCC, 1982). In the present of ultra-violet light the iron cyanide complexes will be broken down to release cyanide ions. In subsurface soils, or turbid waters the rate of free cyanide release for the iron complexes is negligible (NRCC, 1982).

Iron cyanide complexes are much less toxic than free cyanides (NRCC, 1982). They are considered "essentially non-toxic" to aquatic organisms (NRCC, 1982). Dietary studies of iron cyanide complexes at resulted in little or no adverse effects at levels up to 0.5 percent of the daily diet (Food and Drug Research Laboratories, 1969). Workers handling iron cyanide complexed materials over a number of years did not develop any observed adverse effects. It was concluded that the iron cyanide complexes are toxic only to the extent to which they are converted to cyanide ions, which is slow (Hartung, 1982). Iron cyanides have relatively low toxicity because they do not normally liberate cyanide when acidified (i.e., in the stomach) nor are they believed to be metabolized to cyanide in vivo (Arena, 1974).

In summation, it is the complex-forming tendency of cyanide that is the factor that is responsible for the toxicity; cyanide ions form stable complexes with various enzyme metals interfering with cellular respiration (USEPA, 1978). This toxic effect is dependent on the presence of the reactive cyanide ion within the body. Stable iron complexes, such as iron complexes have negligible conversion to ionic or free cyanide. Intake of cyanides that are already complexed will not result in the cyanide complexing with the enzyme metals. Therefore, complexed cyanides have relatively low toxicity (USEPA, 1978).

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FINAL

FEASIBILITY STUDY FOR THE BUCKEYE RECLAMATION LANDFILL ST. CLAIRSVILLE, OHIO

Task 7 of the
Buckeye Reclamation Landfill
Remedial Investigation/Feasibility Study

Submitted by:

Buckeye Reclamation Landfill Steering Committee

Prepared by:

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Versar Job No. 6022.10

April 30, 1991

6022RPT C1C_BUCKEYE_FS_NS_SRS

EXECUTIVE SUMMARY

The Buckeye Reclamation Landfill site is located in eastern Ohio approximately 4 miles south of St. Clairsville, Ohio, in Belmont County. The site has been placed on the National Priorities List (NPL) of uncontrolled hazardous waste sites under the Comprehensive Environmental Response and Liability Act (CERCLA) of 1980.

This Feasibility Study (FS) Report summarizes the process used to develop and evaluate the potential remedial action alternatives for the Buckeye Reclamation Landfill site.

The FS Report contains a multi-step evaluation of the technologies and assembled alternatives by progressing through a series of screenings. General qualitative information is used initially to screen the potential technologies and remedial action alternatives for their applicability at the Buckeye Reclamation site. In later phases of the FS process, more detailed, quantitative information is used to screen the technologies and potential remedial action alternatives.

The ultimate goal of the FS process is to develop a list of potential remedial action alternatives for use at the Buckeye Reclamation site that are consistent with the National Contingency Plan's (NCP) concept of an appropriate extent of remedy. This appropriate remedy is described as a "cost-effective remedial alternative that effectively mitigates and minimizes threats to and provides adequate protection of public health, welfare, and environment" [40 CFR 300.68(i)].

Site Description

The Buckeye Reclamation Landfill site consists of a landfill and waste pit constructed within a narrow valley filled with mine spoil. Near the north end of the landfill is an area known as the waste pit, which is now covered, but formerly was a depression in which industrial wastes (mostly liquids) were disposed.

The landfill is excavated in mine spoil which covers a bedrock ridge and partially buries two drainage ways: Kings Run to the east and Unnamed Run to the west. Approximately half of the Kings Run valley is filled with 50-100 feet of mine spoil. The sedimentary rocks that underlie the ridge on which the landfill and mine spoil deposits occur consist of beds of impure limestone, sandstone, siltstone, and shale up to 300 feet thick, interbedded with at least four major and two minor coal seams. All beds are relatively low permeability. However, limestone, sandstone, siltstone, and coal bed generally bear water in the vicinity of the site, as do the mine spoil and landfilled material.

Remedial Action Goals

The Endangerment Assessment Report identified 12 indicator chemicals as accounting for the majority of the health-based risk associated with the site.

Of the indicator chemicals identified in the endangerment assessment, arsenic, beryllium, and polycyclic aromatic hydrocarbons (PAHs) accounted for the majority of the risks as associated with the soils. The remedial action goal for the soil is therefore to protect public health and the environment by limiting direct physical contact with the waste to reduce the threat of dermal contact, inhalation, and ingestion of soils. In addition to this direct goal, remedial action goals for the soil also include addressing the soil as a source for ground-water contamination and acid mine drainage protection that may impact the waters of the state.

For the ground-water surface water matrix, the RI found no contamination attributable to the site in any of the surrounding pr ate wells, but the site ground water and surface water were impacted by a number of contaminants. The flow of contaminated leachate into Kings Run is of primary concern because of the potential for this surface water contamination to impact the all... aquifer of the Little McMahon Creek south of the site. The remedial action goal for the surface water on the site is therefore to reduce the levels of contaminants in the surface water leaving the site by achieving ARARs for these contaminants. The low-pH waters will also be adjusted to a more neutral value prior to leaving the site.

Remedial Action Alternatives

Four remedial action alternatives (and the No Action Alternative, as required by the National Contingency Plan) were developed and screened for potential application in an attempt to meet the remedial a... goals for the Buckeye Reclamation site. The alternatives that were developed from a list of applicable technologies that resulted from an intensive screening process of potential remedial action technologies.

Nine evaluation criteria have been developed to address the technical and CERCLA policy aspects that have been proven to be important in the selecting the remedial alternatives for a site. The NCP requires these nine evaluation criteria to be considered in remedy selection. The detailed analysis of the remedial alternatives presented in this FS document were based upon the first seven of the nine criteria listed below:

- Overall protection of human health and the environment
- ARARs compliance
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- State Acceptance
- Community Acceptance

The last two criteria, state acceptance, and community acceptance required by NCP are to be evaluated following com... n the RI/FS and on the proposed plan. These two criteria will be addressed in m... he final decision on the remedy and preparation of the Record of Decision (ROD) for th...

A summary of the principal features of the remedial action alternatives developed for the Buckeye Reclamation site is given below.

Alternative 1

Alternative 1 is the No Action alternative which is required by the NCP to be carried through the detailed analysis of alternatives. This option is a no cost alternative that is designed to function as a baseline comparison to the other alternatives involving action. Alternative 1 fails to meet the remedial action goals for the site, and is not protective of human health and the environment.

Alternative 3A and 3B

Alternative 3 utilizes a full RCRA cap to protect the entire site. The cap will eliminate direct contact with contaminated soils, reduce infiltration of rainwater, and minimize the formation of acid mine drainage. Capping will also minimize the formation of landfill leachates. Capping will also minimize the formation of landfill leachates. As with all alternatives involving remedial action, one of two options can be employed for acid mine drainage following collection; these are chemical treatment by neutralization and precipitation (option A), and biological treatment through the use of a constructed wetlands (option B). The total cost of Alternative 3 is approximately $196,913,000 under option A, and $193,084,000 under option B.

Alternative 4A and 4B

Alternative 4 involves the use of a standard landfill cap to protect the entire site. This cap is not as complex as the RCRA cap, but still will be able to effectively eliminate direct contact with contaminated soils, reduce infiltration of rainwater, and minimize the formation of acid mine drainage. Capping will also minimize the formation of landfill leachates. As with all alternatives involving remedial action, one of two options can be employed for treatment of the acid mine drainage following collection; these are chemical treatment by neutralization and precipitation (Option A), and biological treatment through the use of a constructed wetlands (Option B). The total cost of Alternative 4 is approximately $52,492,000 under Option A and $48,663,000 under Option B.

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APPENDICES

1.0 INTRODUCTION

This Feasibility Study report is prepared in fulfillment of Task 7 of the Remedial Investigation Feasibility Study (RI/FS) for the Buckeye Reclamation Landfill (BRL) as described in the Quality Assurance Project Plan (QAPP) for this investigation. The report has been prepared in accordance with the most recent guidance for feasibility studies (U.S. EPA, 1988).

The BRL site consists of a landfill and waste pit constructed within a narrow valley filled with mine spoil. The BRL site is defined as being located " ... on approximately 50 acres of a 658 acre tract ... and such other areas beyond said 50 acre landfill where hazardous substances have come to be located as a result of a release from said landfill" (Administrative Order by Consent, January 26, 1986, page 8, Item G 1).

The remedial investigation at this site was conducted from May 1986 through December 1988. The report of the remedial investigation (RI) was prepared and submitted to the Agencies as a draft on March 23, 1989. A final RI report was submitted August 9, 1989 after addressing comments from the Agencies on the draft. This document was subsequently finalized by the Agencies and approved June 20, 1990.

The FS consists of development and screening of alternatives and detailed analysis of alternatives. Alternatives for remediation are developed by assembling combinations of technologies and their applicable media into alternatives that address contamination on a site-wide basis or for an identified operable unit. During detailed analysis, the screened alternatives are further refined and compared.

1.1 Purpose and Report Organization

The objective of the feasibility study is to screen, evaluate, and recommend remedial actions for the BRL site that are protective of human health. This report documents the analyses and evaluations conducted to develop comprehensive remedial action alternatives for the BRL site. The Agencies will use this information to recommend a remedial action alternative in accordance with the NCP and CERCLA statutory provisions for implementation at the BRL site.

The remedial action objectives for the site focus upon actions to protect human health and the environment via control or elimination of potential contaminant exposure pathways. These include actions to ensure the future immobility of, or to remove permanently the waste constituents in the landfill and waste pit, prevent contamination of site surface waters by leachates possibly originating from the waste pit and/or discharges from the landfill through water-bearing zones, and to prevent public exposure to surficial soils.

The remainder of Section 1 provides background information for the site. describes the results of the remedial investigation. discusses the nature and extent of contamination and summarizes the findings of the Endangerment Assessment.

Section 2 discusses the feasibility study process in general and its application to the BRL site.

Section 3 presents and discusses the remedial action objectives. summarizes site contamination problems including the findings of the Endangerment Assessment. and presents the potential Applicable or Relevant and Appropriate Requirement (ARARs) for the site.

Section 4 discusses the development of general response actions. which are specified by site media. Section 5 describes the phase one screening process for implementability of process options (technologies). Process options surviving the phase one screening are then subjected to a phase two screening for implementability (in more detail), effectiveness. and cost. The results of screening in Section 5 are one or more viable process options within each type of remedial technology.

Section 6 assembles the surviving process options into site-wide remedial alternatives. and evaluates those alternatives relative to each other for effectiveness. implementability. and cost. Alternatives that are duplicative or not cost-effective are eliminated from further consideration.

Section 7 evaluates alternatives which survived screening according to the nine evaluation criteria derived by the U.S. EPA based on statutory provisions in Section 121 of CERCLA, which are: *overall protection of human health: compliance with* ARARs: long-term effectiveness and permanence: reduction of mobility, toxicity. or volume: short-term effectiveness: implementability: cost: State acceptance: and. community acceptance. Section 7 also provides a tabular summary comparative analysis of the alternatives to assist the Agencies in identifying key tradeoffs among alternatives.

1.2 Site Background

1.2.1 General Site Description

The Buckeye Reclamation Landfill (BRL) is located near State Route 214. approximately 4 miles southeast of St. Clairsville and 1.2 miles south of Interstate 70 in Sections 20 and 21 (Township 6 North. Range 3 West). Richland Township. Belmont County. Ohio (Figure 1-1). Interstate 470 is located just south of the landfill entrance and approximately 3.000 feet north of the landfill area.

The BRL site is situated in the Kings Run drainage ravine: it is bordered by Kings Run to the east and Unnamed Run to the west. The landfill extends approximately 3,700 feet north to south and is approximately 500 to 1,000 feet wide. The site on which the landfill is located occupies 658 acres. The landfill occupies approximately 50 acres of this area.

The approximate site boundaries for the RI extend from Kings Run to the east, Ebbert Road to the west, Little McMahon Creek to the south, and Interstate 470 to the north. The valley of Kings Run and the ridge to the west were filled with mine spoil from nearby underground coal mines. Coal mine spoil is comprised of rejected off-specification coal, shale, waste rock, pyrites, and other materials that contain iron, manganese, aluminum, and other metals. A large area of mine spoil also extends into the valley of the Unnamed Run to the west. Placement of the mine spoil resulted in the formation of three surface water impoundments along Kings Run (Figure 1-2). Only the northernmost impoundment, the largest of the three, is still present. Water flows out of the northern impoundment via an overflow pipe that extends under the landfill access road and discharges into Kings Run. Placement of mine spoil into a tributary valley on the ridge west of Kings Run created an impoundment referred to as the Waste Pit. The Waste Pit was filled and covered prior to site investigation.

The landfill descends towards the drainage ravine and gently slopes toward the south. The southern portion of the site is vegetated; barren soils and mine spoil are present over the remainder of the site.

The Kings Run watershed is 1.04 square miles in area and the average fall is about 162 feet per mile. Little McMahon Creek drains an area of 14.42 square miles and flows for 8.3 miles before its confluence with McMahon Creek. The McMahon Creek drainage basin includes 91.2 square miles in Belmont County (J.C. Krolczyk, 1954. Gazetteer of Ohio Streams).

Portions of three abandoned underground coal mines underlie the site. Pittsburgh (No. 8) coal was removed from these mines. Most of the mine spoil deposited at the site was removed from a mine located just south of the site, across Little McMahon Creek.

A reclaimed strip mine is located north of the site, along the ridge separating Kings Run and the Unnamed Run to the west. The Washington (No. 12) coal was strip-mined from the ridge. There is no evidence that any strip-mining occurred within the boundaries of the site.

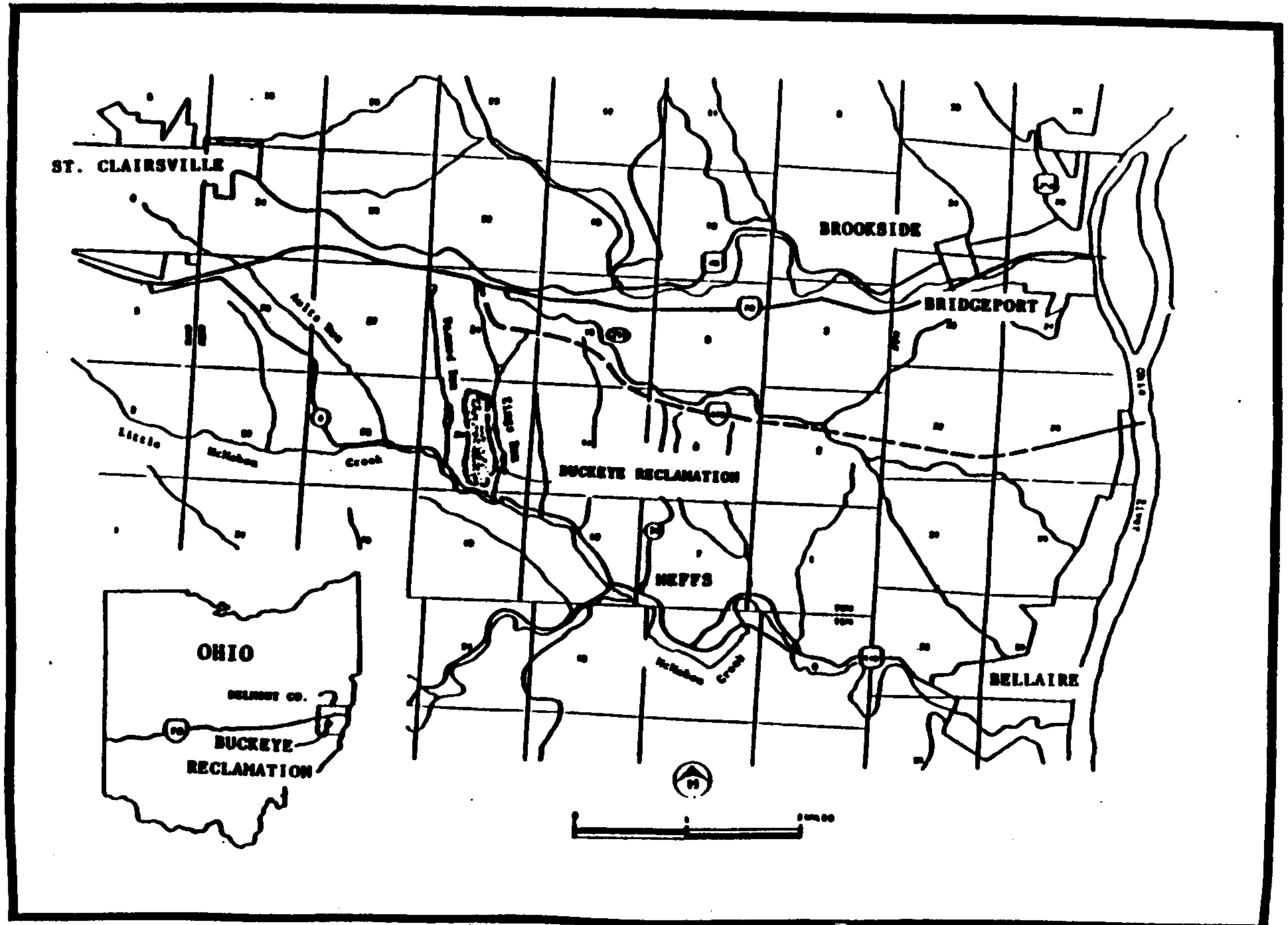
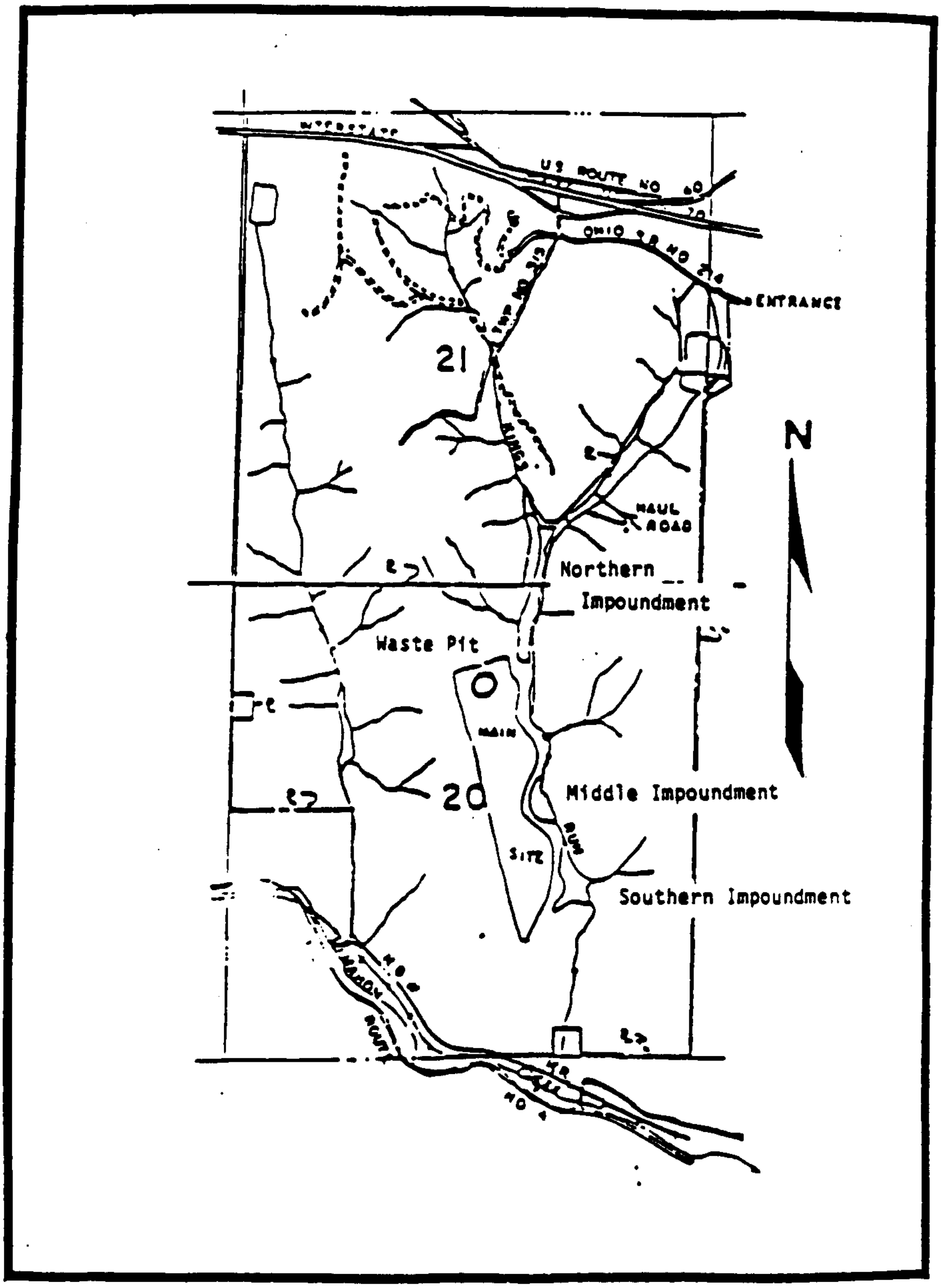


FIGURE 1-1 . LOCATION

FIGURE 1-2. SITE DRAINAGE, 1970 (BEFORE LANDFILL OPERATIONS) (FROM STEGMAN AND SCHELLHASE LANDFILL DESIGN MAP)



1.2.2 Site History

Deep mining occurred beneath and adjacent to the 658 acre site until about the early 1950s. During that time, the site was a disposal area for mine spoil. Mine spoil was removed from the mines and deposited on the ridge west of Kings Run and in the drainage ravine for Kings Run. The area was licensed as a public sanitary landfill in 1971 by the Ohio Department of Health, and is currently owned by Belmont County. It has been operated by Ohio Resource Corporation, under the name of Buckeye Reclamation Company, since that time. As a public landfill (of approximately 50 acres in size) the facility accepts general trash, rubbish, and other materials from municipalities, villages in the county, and the surrounding area.

Detailed records of the actual types and quantities of waste and their on-site location are limited. Woodward-Clyde (1985) cites a 1979 OEPA Solid Waste Disposal Questionnaire indicating the following distribution of materials received by the site.

- 55 percent household
- 20 percent industrial
- 10 percent commercial
- 5 percent agricultural
- 5 percent construction demolition
- 2 percent incineration residue
- 1 percent dead animals

In addition, these records indicate a total waste volume of approximately 950 tons per week or 49,400 tons per year. Use of the Waste Pit had ceased by 1980, when the pit was filled and covered. Soil samples for chemical analysis were taken from seven borings in the general landfill area.

The landfill accepted industrial sludges and liquids, with most of the wastes received between 1976 and 1979. The liquid and sludge disposal is believed by the operator to have been confined to a 5-acre depression (or a portion of it) located in the northern section of the fill area. This area is known as the Waste Pit. Two other potential disposal areas were identified by U.S. EPA before and during the RI: 1) the asbestos disposal area, and 2) the southern impoundment area (Figure 1-3).

1.2.2.1 Waste Pit

Bulk liquids disposal is believed by the operator to have been confined to the Waste Pit. Solid wastes (i.e., asbestos, carbon black) were disposed with municipal wastes elsewhere in the landfill. Industrial sludge was spread upslope from the Waste Pit. (This sludge was later covered in place.) In 1980, the Waste Pit was filled by pushing mine


BUCKEYE RECLAMATION LANDFILL RI/FS
FIGURE 1-3 SITE MAP SHOWING LOCATIONS OF THREE POTENTIAL DISPOSAL AREAS FOR INDUSTRIAL WASTES
SCALE IN FEET
0 200 400
WASTE PIT
ASBESTOS DISPOSAL AREA
SOUTHERN IMPOUNDMENT
APPROXIMATE LIMIT OF LANDFILLED AREA

spoil and overburden soil into the impoundment. The area was then covered with clay, shale, and soil graded from upslope areas and seeded to grass. A low soil berm was graded in place around the Waste Pit to route surface flow around the area and prevent erosion.

Estimated total volumes of industrial wastes received are 4.7 million gallons of liquid and 3,300 tons of solid wastes (Woodward-Clyde, 1985). Most of this material is believed to have been disposed of in the Waste Pit between 1976 and 1979. The materials believed to have been disposed of in the Waste Pit include (Woodward-Clyde, 1985):

- Asbestos
- Benzene
- Benzoic acid
- Fumaric acid and washings
- Various industrial sludges
- Maleic acid
- Maleic anhydride solution
- Naphthalene
- Oils
- Paints and varnishes
- Phthalic acid
- Sodium sulfate or sulfide
- Xylene

To determine the types of wastes and concentrations present in the Waste Pit, five borings were advanced in the area. Soil samples from four of the borings were taken for chemical analysis. Soil samples from the fifth boring were used to determine physical characteristics.

1.2.2.2 Asbestos Disposal Area

Asbestos was also disposed of in a separate area of the landfill. The area is believed by the operator to have been limited primarily to the southern filled areas of the landfill (Figure 1-3). The asbestos was generated by a brake block manufacturing facility and was disposed of at the landfill with other solid waste materials. The generator has indicated that the asbestos may have been delivered in plastic bags although this has not been confirmed. Information concerning the size of the bags was not available.

1.2.2.3 Southern Impoundment Area

The southern impoundment was present at the landfill as early as 1970 and is clearly shown on a pre-landfill topographic map prepared for the Buckeye Reclamation Company by Stegman and Schellhase, Inc. (1970). At the time of the 1970 mapping, the impoundment contained water with the surface of the water standing at 917.0 feet (MSL) elevation. (The southern impoundment was originally formed by damming the course of Kings Run with mine spoil.)

In 1975, the water was drained from the impoundment to allay the concerns of residents downslope that the impoundment could break, causing flooding. Current long-term employees of the Bu: ve Reclamation Company and long-term county officials in charge of inspecting the landf. report that after the impoundment was opened, portions of the bottom of the depression were lined with old tires to restrict soil erosion and provide a base for subsequent landfilling operations. (The area was not mapped at this time. Therefore, exact measurements of the elevation of land surface are unavailable. However, extrapolation of topographic contours on the 1970 Stegman and Schellhase map indicate the elevation at the bottom c' the impoundment could have ranged from 905 feet in the north part to 895 feet in the southern part.)

After the depression was lined with tires, the area was used for disposal of domestic garbage by the standard fill-and-cover method. The 1983 topographic map prepared by Burgess and Nic e. Ltd. indicates land surface elevation in the area of the southern impoundment at 935 to 965 fee MSL). The 1" to 100-foot scale map prepared for this project indicates present land s. ace elevation at 935 to 965 feet (MSL) in the area of the Southern Impoundment. Therefore, no landfilling occurred in this area after 1983, the date of the Burgess and Niple mapping. If disposal of neutralized pickle liquor sludge had occurred, would have been between 1975 (when the impoundment was drained and lined with tires and 1983 (the date of th Burgess and Niple mapping).

In order to evaluate the possibility that neutralized pickle-liquor sludges were present at this location, three boreholes were advanced and split-spoons were collected for a visual inspection and field screening of split-spoon sampled (collected continuously) from the southern impoundment with photoionization and flame ionization detectors. The Agencies believe that this information is inconclusive.

1.3 Remedial Investigation

A Remed a Investigation (RI) was conducted at the Buckeye Reclamation Landfill (BRL) in St. C.airsville, Oh o by Versar, Inc. under contract to the Buckeye Reclamation Landfill Steering Committee. n accordance with the Administrative Consent Order agreement with U.S. EPA Region V and Ohio EPA. Waste Characterization activities included an electromagnetic conductivity (EM) survey and borings and analyses of samples in the Waste Pit area. Soil borings and analyses were also conducted in the general landfill area and in background locations. Evaluation of contaminant migration pathways included surface water, air, and hydrogeologic investigations, and sampling of domestic water supplies.

Additional RI activities conducted included ground-water sampling from twenty-one on-site wells, ground-water sampling from seven off-site wells, on-site surface water sampling from nine surface water stations, leachate sampling from six locations, and sediment sampling from eight of the surface water monitoring stations.

1.3.1 Summary of Activities and Findings

The remedial investigation involved extensive evaluation of the geology and hydrogeology of the site and detailed evaluation of the nature and extent of contamination in various environmental media and transport pathways. These media and pathways included the following:

- Waste Pit and surrounding soils.
- Surficial soils.
- Landfill soils, including an area designated the Asbestos Disposal Area and a third area of alleged disposal known as the Southern Impoundment.
- Leachates from the Waste Pit mine spoil/garbage and from the landfill mine spoil and garbage.
- Surface water in Kings Run (which runs through the site), a small tributary to the west of the site known as Unnamed Run (which is unaffected by the site, and Little McMahon Creek which is fed by Kings Run and Unnamed Run).
- Runoff from the Waste Pit and Asbestos Disposal Areas.
- Sediments in Kings Run, Unnamed Run, and Little McMahon Creek.
- Air emissions from the Waste Pit and Asbestos Disposal Area.
- Ground water in the following six water-bearing zones.
  - Wegee limestone, which is contiguous with the Waste Pit
  - Waynesburg coal, which is contiguous with the Waste Pit
  - Uniontown sandstone, which is near and immediately beneath the Waste Pit
  - The mine spoil water-bearing zone, which underlies most of the site and is associated with a virgin soil confining layer that predates and underlies most of the landfill and mine spoil, but is locally breached along the former Kings Run drainage
  - Benwood limestone, which underlies most of the site

- Redstone limestone, which underlies the site and is contiguous with off site units

- Domestic wells located in the alluvial valley of Little McMahon Creek, and one spring located near the site and emerging from the Benwood limestone.

Additional evaluations included a survey of fish and benthos in Kings Run, Unnamed Run, and Little McMahon Creek to assess the impact of discharges from the site on Little McMahon Creek.

The results of the EM survey conducted prior to drilling and sampling at the Waste Pit indicated that no metallic drums or other large metallic objects were present in the subsurface and that no contaminant plumes were distinguishable within the original boundaries of the Waste Pit. Comparison of pre-landfilling and present-day topography indicated that the Waste Pit was irregularly conical in shape extending to a depth of not more than 55 feet below present grade.

The results of the Waste Pit boring program corroborated previous information on the physical make-up and later filling of this area. The upper part of the Waste Pit consists of mine spoil and silt, mine spoil and garbage, and a clay cap. The Waste Pit is floored by virgin soil and clay overlain by clay and silt containing graded gravels typical of sediments deposited in standing water. Because these deposits are free of garbage and, therefore, undisturbed by landfilling activities, the base of the Waste Pit is broadly defined by these deposits. Based on historical map information supported by geologic information from these borings, it can be concluded that the Waste Pit was originally an impoundment formed by the damming of a small ephemeral stream with mine spoil.

Samples were collected from four borings within the boundaries of the Waste Pit. Two distinct peaks in the organic contaminant concentration were identified within the Waste Pit: 1) a peak roughly between 1070 and 1079 feet mean sea level (MSL), and 2) a peak between 1055 and 1065 feet MSL. Contamination concentrations decreased markedly above and below these depths. No asbestos or PCB's were detected in any of the borings. Heavy metals were broadly distributed through the Waste Pit materials with localized high concentrations of chromium and zinc. Pesticides were detected in only 2 samples.

Detailed geologic profiles of the site were obtained using readily available topographic maps of the landfill area and borings advanced for the RI. The first detailed map of the landfill area, the 1905 St. Clairsville U.S.G.S. 15 Minute quadrangle, shows the original topography of the valley before the mine spoil was emplaced. The virgin soil confining layer was observed repeatedly in soil borings and corresponds to the 1905 topographic surface. By overlaying the 1905 topographic map onto the 1987 site base map and correlating these surfaces with geologic information from soil and rock borings. detailed cross-sections were developed between major boreholes.

Twelve soil borings were advanced in this unconsolidated material of the general landfill. Samples from seven of these borings were collected for physical description and chemical analyses. Samples from the other five borings were collected for physical description only. A pre-landfill mine spoil layer overlies a virgin soil layer at all locations except MW-5C and MW-10C. However, is believed to be absent in the old stream bed of the buried ancestral drainage of Kings Run. Deposits of mine spoil and garbage. mine spoil and silt fill, and clay cap are found above the mine spoil.

In the general landfill outside the Waste Pit, volatile organic compounds detected in the borings include methylene chloride, acetone, benzene, toluene, ethyl benzene, and xylene. The major semivolatile organic compounds detected include naphthalene, 2-methylnaphthalene, dibenzofuran, phenanthrene, bis(2-ethylhexyl)phthalate, and chrysene. These compounds were also detected in a soil sample collected outside the landfill and areas affected by mine spoil disposal (MW-0A). Low levels of pesticides were detected in samples MW-12Ax and MW-9A. No PCBs were detected in any samples. Heavy metals were detected throughout but generally at concentrations comparable to (or slightly higher than) those found in soils affected only by mine spoil disposal. Asbestos was detected in samples from MW-12Ax and MW-9A at weight percentages ranging from 1×10^{-5} to 5.9×10^{-4}.

A network of 25 monitoring wells was installed throughout the site to monitor the unconsolidated material (mine spoil and garbage) above a contiguous confining layer identified as the virgin soil confining layer (defined in the plans for the project as a shallow upper zone) as well as several bedrock aquifers including the Wegee limestone, Waynesburg coal, Uniontown sandstone, and Benwood limestone (deep upper zones), and an aquifer which underlies the entire site, the Redstone limestone (deep zone). Nested conductor casings were used to isolate these zones during drilling to minimize cross-contamination between zones. Geologic cross-sections have been developed for the site based on detailed geologic information obtained during drilling. An extremely regular bedrock geology was observed through correlation of continuous core and logging.

Ground-water surface elevations were measured during both the March and the May, 1988, ground-water sampling events. These measurements were used to prepare hydrogeologic cross-sections and potentiometric contour maps. The hydrogeology of the mine spoil water-bearing zone appears to be controlled by the original "pre-mine spoil" topography. Ground water generally flows north to south in the mine spoil and Benwood limestone water-bearing zones. The mine spoil water-bearing zone is primarily recharged from three sources; the surface impoundment, Kings Run, and infiltration from the ridgetop to the northwest. Direct infiltration is limited by the clay cap and compressed layers of garbage and fill. The primary source of recharge to the Benwood limestone appears to be the surface impoundment although vertical leakage through outcrops and subcrops are also likely where the virgin soil layer is absent.

Potentiometric surface elevations in the Wegee limestone, Waynesburg coal, and Uniontown sandstone indicate northerly, southwesterly, and northwesterly flow directions, respectively. Recharge from the shallow upper zone induces this flow to the northwest and north. However, the southeastern dip of the strata would tend to limit the areal extent of the influence from a southeast or northeast recharge.

Potentiometric surface elevations in the Redstone limestone indicate a recharge source to the south. The difference in potentiometric surface elevation between MW-10C and MW-12C suggests recharge to the Redstone limestone by hydrostatic pressure at the subcrop in a fashion similar to the bedrock units near the Waste Pit. All bedrock formations show no indication of any substantial primary porosity or permeability. Ground-water yields are the result of secondary porosity and permeability at joint faces, coal cleats, and along bedding planes.

The overall ground-water quality of the area is rich in inorganic constituents. Total dissolved solids (TDS) in the mine spoil water-bearing zone are generally very high (3,000 to 5,000 mg/l in most wells and up to 8,380 mg/l in MW-7A). Some bedrock TDS levels are comparably high; the TDS ranges in bedrock wells are considerably lower (generally, 1,000 to 2,000 mg/l) but increase to 3,000 to 3,500 at monitoring wells near the influence of recharge from the shallow mine spoil water-bearing zone.

A number of contaminants were detected in several water-bearing zones. However the distribution of these analytes shows no systematic pattern indicating a well-defined plume from the Waste Pit, with the possible exception of benzene (MW-4A, MW-8A, and MW-8B) and no definable plume associated with the general landfill. However, contaminants may be migrating from the Waste Pit short distances through ground water and through leachates near the Waste Pit, and discharging to surface water.

Nine surface water stations were constructed to monitor surface water-quality during baseflow and storm flow conditions in Kings Run, Unnamed Run, and Little McMahon Creek. Two surface runoff stations were installed to monitor storm events.

Kings Run, Unnamed Run, and Little McMahon Creek are all affected by depressed pH and other typical effects of acid mine drainage such as elevated concentrations of metals. Concentrations of most inorganic constituents generally increase from upstream to downstream locations, as would be expected.

Very few organic compounds were detected in surface water samples, with the exception of common laboratory contaminants. Where detected, organic compounds were at extremely low concentrations at or near detection levels. Arsenic, barium, chromium, lead, mercury, silver, and selenium were detected at elevated concentrations in some locations.

Eleven sediment samples were collected near surface water stations. Other than common laboratory contaminants, no volatile organic compounds were detected in any of the sediment samples. Nine semivolatile organic compounds typical of the composition of undisturbed mine spoil were detected. The concentrations of all of these contaminants were more than an order of magnitude less than concentrations in the mine spoil. The distribution of metals in sediment varies between the different drainages, but metal concentrations are generally higher in upstream locations because these locations are less affected by dissolution of these metals (this dissolution is a result of the elevated pH characteristic of AMD).

Six sampling locations were selected to provide data on leachates/springs on the BRL site and in the Unnamed Run drainage. Three leachates were sampled in the immediate vicinity of the Waste Pit area (L-1, L-2, and L-5). Of these, only L-2 has the potential of being affected by the Waste Pit. Leachate L-1 emerges from mine spoil and garbage and L-5 emerges from mine spoil. A sampling location was also selected in the Unnamed Run drainage (L-6) to provide additional information about acidic leaching of mine spoil materials unaffected by any contaminants from the Waste Pit or the landfill. All of the leachate sampling locations except L-3 are affected to some degree by the presence of mine spoil in the immediate vicinity of the sampling location. The leachate sample from the Benwood limestone, L-3, although identified as a leachate for the purposes of this investigation, is more correctly termed a spring. The leachate at the toe of the landfill (L-4) is a major discharge point for the mine spoil water-bearing zone.

Several volatile and semivolatile organic compounds were detected in leachates from the Waste Pit/mine spoil/garbage and from the mine spoil and garbage.

Metals concentrations were elevated for arsenic (L-5 and L-6), cadmium (L-5 and L-6), and chromium (L-5 and L-6). Because L-5 and L-6 represent pre-landfill conditions for acidic leachate unaffected by the Waste Pit or landfill, these data indicate that much of the contaminant loading in surface water for these metals and much of the ground-water contamination for these metals are the result of leaching from the mine spoil, rather than from waste disposal activities associated with the operation of the site.

Asbestos fibers were not present in samples collected during quantitative air sampling at the Asbestos Disposal Area. Some volatile organic compounds present in the Waste Pit soils are possibly being released in low concentrations to the air, but firm conclusions cannot be made due to high up-wind contaminant concentrations in the area of the site. The rate of release is very slight, even under weather conditions ideal for maximum concentrations to occur (such as high ambient air temperatures and light winds). Heavy metals are either present in extremely low concentrations or absent altogether in sample air collected at the site.

With respect to aquatic ecosystems, all sites surveyed appeared to be impacted and results of both fish and macroinvertebrate surveys demonstrated a pronounced gradient in stream water quality in the vicinity of the site. The scarcity of benthic macroinvertebrates and the absence of fish in downstream locations on Kings Run and Unnamed Run suggests that the instream environment is extremely poor at these sites, with conditions in Unnamed Run being least favorable to living organisms.

Along Kings Run, abundance and richness of both fish and benthic macroinvertebrates declines from below the impoundment to Little McMahon Creek, but the decline in fish abundance was much more rapid than the observed gradient in benthic macroinvertebrate abundance. A similar phenomenon was also observed in Little McMahon Creek; the fish population exhibited much more drastic reductions in numbers than benthos going downstream, suggesting that environmental stress is near the lethal threshold when organisms, especially fish, are exposed to water from Kings Run and Unnamed Run.

The data clearly show that fish and benthos are strongly impacted by poor quality water from Unnamed Run primarily and, to a lesser extent, from Kings Run. The effect from discharges from mine spoil is so severe, however, that the effects from any contamination arising from the Waste Pit or the general landfill is statistically unobservable.

1.3.2 Nature and Extent of Contamination

The focus of the remedial investigation was on possible migration of hazardous substances from the Waste Pit at the northern end of the landfill. Complete analytical results from the borings are contained in Appendix C of the RI report (Versar 1989). Of the compounds detected, the RI report (Versar 1989, revised by Ohio EPA and U.S. EPA 6/90) identifies six contaminants potentially indicative of the Waste Pit, due to significantly higher concentrations compared to concentrations found in mine spoil or mine spoil plus garbage. These contaminants are benzene, toluene, ethylbenzene, total xylenes, chromium, and zinc.

Maximum concentrations of benzene, toluene, ethylbenzene, total xylenes, chromium, and zinc were 19,000 µg/kg, 142,000 µg/kg, 303,000 µg/kg, 907,000 µg/kg, 276 mg/kg, and 20,400 mg/kg, respectively. The maximum concentrations of benzene, toluene, ethylbenzene, and total xylenes in the Waste Pit borings were all from WP-2 at depths at

12 to 15 feet. Maximum concentrations of chromium and zinc were from WP-4, at depths of 21 to 24 feet.

From general landfill and mine spoil borings, maximum concentrations of benzene, toluene, ethylbenzene, and total xylenes were all from boring MW-2Ax, at a depth of 20 to 25 feet. These values are 94 µg/kg (81 on reanalysis), 240 mg/kg (220 on reanalysis), 45 µg/kg (39 on reanalysis), and 150 µg/kg (130 on reanalysis), respectively. The maximum concentration of chromium (38 mg/kg) was found at a depth of 15 to 18 feet in boring 3AA. The maximum value of zinc (3,650 mg/kg) was found at a depth of 20-25 feet in boring 9A.

It is expected that contaminants present in the ground water (or those that could migrate to the ground water) would be transported in the same direction of ground-water movement. Ground-water movement on the site is not well defined due to the extremely complex hydrogeology. Ground water in some water-bearing zones might be expected to move eastward, in accord with the slope of the land. The Waste Pit indicator compounds found in MW-7A, MW-4A, MW-8A, and MW-8B, all of which are located in the suspected downgradient direction from the Waste Pit, support the hypothesis that contaminants may have moved some distance from the Waste Pit.

Low concentrations of the indicator volatile organic compounds (VOCs) were detected during only one of the three sampling rounds of the leachates and springs at Leachate L-2. The indicator metals were reported in all leachates, except the Benwood spring (L-3) (Versar, 1989), during all three sampling rounds. Leachate L-6, located a half-mile southwest of the Waste Pit in the valley of Unnamed Run and well beyond the landfill, reported the highest concentrations of chromium and zinc. It is unlikely that the water in the Waste Pit soils would move westward towards Unnamed Run contrary to the slope of the land surface, but that possibility cannot be totally discounted.

None of the VOCs or chromium were found during the sampling of the six domestic wells and one domestic spring located in or near the valley of Little McMahon Creek. Zinc was found in all the wells with the highest concentration at 226 µg/l. No zinc was reported in the domestic spring.

None of the indicator VOCs are reported from any surface water source sampled during the RI. The indicator metals concentrations were relatively high. The concentration ranges of 14 to 219 µg/l and 28 to 1,030 µg/l for chromium and zinc, respectively, considering the data from Kings Run and Little McMahon Creek together. It is not possible to determine if these values suggest an origin for the contaminants in the Waste Pit or simply reflect the general character of the landfill and mine spoil materials.

The sediment samples reported only trace indicator VOCs and low concentrations of the indicator metals. These values are of little significance with respect to the origin of the contaminants.

1.3.3 Endangerment Assessment Summary

The Endangerment Assessment (EA) examined the non-cancer hazards and cancer risks associated with a group of 12 indicator contaminants which are representative of chemicals which may account for the majority of the health-based risk at the site. The hazards/risks attributable to these analytes are compared to hazards/risks associated with pre-landfill conditions (conditions which would include contamination levels resulting from mine spoil). The exposure assessment examined presently existing exposures for the site, as well as exposures which could result from future land use activities. Exposures and hazards/risks for indicator contaminants detected in residential wells in the vicinity of the site were also examined.

None of the existing exposure pathways were associated with significant noncarcinogenic hazards for either the site or pre-landfill conditions. Of the existing exposure pathways identified for the site, the possible inhalation of fugitive dusts resulted in cancer risk estimates associated with adverse human health effects. Soil concentrations of arsenic and chromium were the primary sources of these increased estimates. These results indicate that bikers, hunters, hikers or other such trespassers may be subject to potential health effects from the inhalation of contaminated fugitive dusts or dermal contact with soils or dusts from the site. At the same time, it must be noted that contaminant concentrations in windblown dusts were determined from a modeling effort and not actual ambient air monitoring at the site. Conservative assumptions were included in these calculations which may or may not result in overestimates of exposure concentrations.

The potential exposure pathways provided exposure concentrations for the site which were, for nearly all cases, higher than pre-landfill concentrations. These contaminant levels in ground water and surface water were also associated with noncancer hazard and cancer risk estimates (for all exposure media) which exceeded the standard hazard index of 1.0, and the cancer risk level of 1.0×10^{-6}, respectively. Such exposures could potentially cause adverse effects in humans at the site under a future use scenario. On an individual basis, the Agencies believe that ingestion of surface water and ground water from the Redstone limestone and mine spoils water-bearing zones were pathways which contributed maximally to the total noncancer hazard for the potential exposure pathways. When the individual pathway hazards for these chemicals are evaluated and grouped according to chemical-specific critical effects, the primary contributors to hazard indices which are greater than unity include: arsenic, chromium, cadmium, carbon tetrachloride, and 1,1-dichloroethene.

With respect to cancer risk, the levels of contaminants in all of the aquifers and in surface water were associated with risks which exceeded 1.0×10^{-6}. The indicator chemicals were not detected in the pre-landfill ground-water samples, or were found at lower concentrations than the levels found in other media at the site, thus precluding the attribution of these risks to pre-landfill conditions. Further examination of the specific chemical risks reveals that arsenic provides a major contribution to the excess risk in all the potential exposure pathways (ground water, surface water, and soils). Benzene also contributes to the excess pathway risks for ground-water ingestion and inhalation of VOCs during showering with ground water. Carbon tetrachloride and 1,1-dichloroethene risks are elevated for ground-water ingestion, inhalation, and/or dermal contact (with the exception of the Redstone and Wegee limestone aquifers). PAH risks were elevated for surficial soils ingestion. Arsenic and benzene provide the greatest overall input to the pathway-specific risks in terms of the frequency at which these compounds exceed pre-landfill risk estimates and the 1.0×10^{-6} increased cancer risk benchmark.

For some chemicals, noncancer hazards and cancer risk estimates for pre-landfill conditions were also in excess of acceptable limits, although these hazards/risks were not as high as the values found for the site. These results indicate that some portion of the excess hazards/risks at the site may be attributable to pre-landfill conditions.

Three indicator chemicals were identified in the off-site residential well water: cadmium, lead, and toluene. The results for analyses were examined under the potential (chronic/lifetime) exposure scenarios (i.e., ingestion, dermal contact, and inhalation of VOCs while showering). The hazard estimates for the off-site residential wells do not indicate any excess hazards from cadmium, lead, or toluene for the exposure scenarios where the wells are utilized as the primary potable water source. Comparatively, the three indicator chemicals found in the off-site residential well water were not chemicals which presented health hazards/risks on-site (for either existing or potential exposure pathways). These findings may indicate that the on-site chemicals of concern are not impacting off-site residential wells. Lead levels in the soils on the site were consistently less than 110 mg/kg. Similarly, lead levels in ground-water samples on-site were below the MCL of 0.05 mg/l. Toluene (a noncarcinogen) was not found to occur at levels associated with noncancer health effects at the site. Cadmium levels did not contribute to increased hazard/risk estimates (compared to pre-landfill levels) in the potential exposure pathway calculations.

In summary, it appears that the concentrations of compounds at the Buckeye Reclamation site could potentially result in human health effects from both existing and potential exposure routes. From a noncancer hazard standpoint, exposures associated with potential future use activities involving ground water or surface water utilization are of primary concern. However, the Agencies believe that contaminant levels in the environmental media at the site are associated with unacceptable cancer risk estimates for exposures which conceivably may presently exist at the site, as well as for potential future use exposure. Excess cancer risk estimates were identified for exposures to site soil, ground water, and surface water. Comparison of these total hazard and cancer risk estimates to pre-landfill results indicates that the excesses are not totally attributable to pre-landfill conditions. For the future use scenarios, contaminants were either undetected in the pre-landfill samples or occurred at lower levels than in the site samples.

While some exposure routes identified as potential exposure pathways may not present risks to human populations, they may be very relevant to potential effects on the flora and fauna at or in the vicinity of the site. The fish and wildlife in the vicinity of the site may be affected by exposure to site contaminants. The potential for adverse effects from contaminant uptake by fish or wildlife could be passed on to humans if they consume fish or wildlife from the site.

2.0 THE FEASIBILITY STUDY PROCESS

2.1 Introduction

The Feasibility Study (FS) for the BRL site develops an appropriate range of waste management options that are screened for effectiveness, implementability, and cost, relative to other options within the same technology type. These remedial options are developed specifically by site media (e.g., surface water, soil, leachate, ground water). Next, the media-specific process options are combined into comprehensive, site-wide remedial alternatives. These alternatives are then screened in more detail for effectiveness, implementability, and cost. During this phase of screening, options for source containment (e.g., capping) may be compared to options for source elimination (e.g., treatment). Those alternatives that survive this screening are then subjected to detailed evaluation based on nine criteria derived from statutory provisions in Section 121(b)(1)(A) of CERCLA. The results of this assessment are arrayed to compare the alternatives and to identify the key trade-offs among them. This approach to analyzing alternatives is designed to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD).

2.2 Summary of Elements

This section of the report discusses each element of the FS process as an overview and guide to subsequent sections. The first step in the FS process is to establish remedial action objectives. These objectives were first developed during the RI for the BRL site, and were refined as much as possible based on interpretation of the RI findings. Section 3.0 of this report discusses general, site-wide and media-specific remedial objectives. These remedial objectives for the BRL site were assembled based on site characterization data, the stipulated applicable or relevant and appropriate requirements (ARARs) developed by EPA for the BRL site, and the findings of the site endangerment assessment, which are each discussed in Sections 1.0 and 3.0 of this report.

After remedial action objectives are established, general response actions describing which containment, treatment, or removal actions that may be applied to each site media (ground water, surface water, leachates, and soils) are assembled. This step is discussed in Section 4.0 of this report.

Section 5.0 of this report identifies potential treatment and disposal technologies for each general response action. These technologies are screened for implementability, eliminating from further consideration those technologies that cannot be technically implemented at the BRL site. Also in Section 5.0, the process options that survive implementability evaluation are subjected to a second-stage screening for implementability, effectiveness, and relative (order-of-magnitude) cost. Representative processes are chosen for each technology type, but processes in different technology types are not compared to one another.

The surviving media-specific technologies are combined into site-wide remedial alternatives that constitute com[illegible]sive remedial plans. The site-wide remedial alternatives are screened base[illegible] effectiveness, implementability, and cost. As many alternatives as possible are eliminated prior to detailed evaluation. This screening step is presented in Section 6.0 of this report.

In Section 7.0 the remedial alternatives surviving screening are evaluated in detail, based on criteria derived from CERCLA statutory provisions. This evaluation is performed to provide the EPA decision-makers with sufficient information to compare the alternatives, select an appropriate remedy, and meet CERCLA remedy selection requirements in the ROD.

3.0 REMEDIAL OBJECTIVES

3.1 Introduction

The general objectives of remedial actions at CERCLA sites are stipulated in the National Contingency Plan (NCP). Consistent with this provision, the remedial action objectives developed for the BRL site are intended to minimize and mitigate specific potential threats to human health or the environment, adequately and permanently protecting human health and the environment.

3.2 Remedial Action Objectives

The Remedial Investigation at the BRL site identified the approximate concentrations and locations of the contaminants on site. Twelve indicator chemicals were selected in the Endangerment Assessment (EA) as accounting for the majority of health-based risk from the conditions at the site. These chemicals are:

- Arsenic
- Benzene
- Beryllium
- Cadmium
- Carbon Tetrachloride
- Chromium
- 1,1-Dichloroethene
- Lead
- Nickel
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Toluene
- Trichloroethene

The remedial action goals for the site are developed for protection of human health and the environment from the site contaminants. These goals, and the subsequent development of response actions to satisfy these goals, must comply with the current National Contingency Plan (NCP) and the requirements of the Comprehensive Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

The health and environmental risks identified in the EA provide the basis for establishing the remedial action objectives for the site.

The EA indicates that there are three significant exposure and contaminant pathways existing on the site. These pathways are:

- Dermal contact/inhalation/ingestion of surface soils.
- Migration of contaminants from surface and subsurface soils into ground water/surface water.
- Ingestion of contaminated ground water/surface water.

The following media, therefore, present an existing or potential threat to public health and the environment:

- Surface/Subsurface Soils
- Ground Water/Surface Water

Although the subsurface soils present no current threat to human health, they are a source for continuing ground-water contamination resulting from rainwater infiltration through the contaminated soils and into the ground water. The contaminants of concern, the cleanup levels for these contaminants, and the remedial action goals for the soil and water matrices are detailed separately in the following sections.

Based upon the evidence presented in the Final Remedial Investigation Report, the water contamination problems associated with the site (both ground water and surface water) can be addressed by remediating the surface water. The sedimentary rock that underlies the ridge on which the landfill and mine spoil deposits occur receives discharge by infiltration of precipitation, largely on the outcrops on the sides of the ridge. This complex collection of various water-bearing units present beneath the site makes characterization of the regional ground water beneath the site difficult, at best. One aspect of the ground-water flow that may be surmised from the data, however, is that most of the water that enters the consolidated rocks is eventually discharged to the surface, largely through lateral flow. The ground water, after being discharged to the surface, will be treated along with surface water.

Additional hydrogeologic investigation will be necessary to provide further data on the extent of ground-water contamination and to determine the potential for contaminated ground water to discharge beyond the proposed collection drain.

Furthermore, the data in the Remedial Investigation Report suggest that local water supplies are currently not threatened by the site ground-water contamination, but that the elevated levels of contamination in the surface water could potentially lead to future contamination in the alluvial aquifer in the Little McMahon Creek valley which is used by local residents. The water remediation technologies for the site will therefore focus on surface water remediation as a means to reduce the threat posed by the contaminants within the water matrix on the site.

The soils at the site have been contaminated with both inorganic and organic contaminants due to the waste disposal activities and the presence of mine spoil. Soil samples collected during the RI indicate that soil contamination by both organic and inorganic constituents exists throughout the site. The compounds that present the most serious health risks in the soil consist mainly of inorganics from the landfilling practices and mine spoils.

The population potentially at risk via dermal contact, ingestion, or inhalation of the soil at the site consists of those people who trespass onto the site, and those who work on the site. Local neighboring residents can currently enter the site at will as access to the site is not restricted.

The EA identified arsenic, beryllium, and polycyclic aromatic hydrocarbons (PAHs) as having an excess cancer risk of above the 1×10^{-6} level. Existing pathway site health risks for the soil matrix includes a maximum excess cancer risk of 1.04×10^{-3} (for Dirt Bike/Trespassers Exposure Scenarios) and the potential pathway risk upon development of the site poses an additional maximum excess cancer risk of 4.52×10^{-5}.

The remedial action goal for the soil on the Buckeye Reclamation site is, therefore, to provide protection of public health and the environment. This can be accomplished by limiting direct physical contact with the contaminated soil to reduce the threat of dermal contact, inhalation, and ingestion of soils. In addition, the remedial action goal for the soil at the site includes addressing the potential for contaminated soil to act as a source for future ground-water contamination. This goal is of utmost importance because the probability of off-site migration of the contaminants from the soil to ground water and eventually to surface water.

The population potentially at risk from the contaminated surface water are those local residents using the underlying alluvial aquifer in the Little McMahon Creek valley as their water source in the vicinity of the site. Although sampling from surrounding private wells revealed no contamination attributable to the site, sampling of the surface water in Kings Run revealed the presence of several inorganic contaminants that exceed Federal drinking water standards. These maximum contaminant concentrations and respective Water Quality Criteria (WQC) for Discharge to Surface Water Near a Potable Water Intake are as follows:

Chemical	Maximum Site Concentration (mg/l)	Water Quality Criteria for Discharge to Surface Water near Potable Water Intake (mg/l)
Arsenic	9.2×10^{-2}	2.5×10^{-5}
Beryllium	1.1×10^{-2}	3.9×10^{-6}
Lead	0.118	5.0×10^{-2}
Nickel	0.454	1.5×10^{-2}
Chromium	1.0×10^{-2}	8.0×10^{-4}

The EA revealed a maximum concentration increased cancer rate of $1.57 \times 10^{-}$ for existing surface water exposures, and a maximum concentration increased cancer rate for potential exposures of 2.56×10^{-3}. These high excess cancer rates for potential exposures to the surface water matrix are primarily from arsenic and beryllium contamination. In addition to the carcinogenic risk, a noncarcinogenic risk factor in excess of 1.0 (i.e., having a significant noncarcinogenic risk) was identified for both the average site surface water sample concentrations for potential exposures (risk factor = 1.31) and maximum site surface water concentrations (risk factor = 5.69). These noncarcinogenic risks are due *primarily to arsenic and chromium contamination.*

The acid mine drainage aspects of the site further complicates the overall site contamination problem. Acid mine drainage is the natural by-product of the oxidation of iron in the mine spoil that is found throughout the site. The acidity of the waste stream not only produces a low pH leachate which is detrimental to the environment in itself; but also the acidic leachate acts as a strong solvent that mobilizes many contaminants in the soil that would normally be stable in a neutral environment. Kings Run is currently at a pH of approximately 3.0; this must be brought to a more neutral value (7.0) to be more compatible with aquatic life.

Based on the above conditions, the remedial action goal for the surface water at the Buckeye Reclamation site is to restore the surface water to a useful, less threatening state by reducing the levels of the contaminants present. The proposed target cleanup level goals are to achieve ARARs for surface water cleanup, as well as to achieve a hazard index of <1.0 and an overall increased cancer risk of $<1 \times 10^{-6}$. The physical parameter of pH of the surface water must also be addressed to benefit the environment; a more neutral pH range of 6.0 to 8.0 will be the goal for surface water leaving the site.

3.3 Potentially Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121(d) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that fund-financed, enforcement, and federal facility remedial actions comply with requirements or standards under federal and state environmental laws. The requirements that must be complied with are those that are applicable or relevant and appropriate to the hazardous substances, pollutants, or contaminants at a site, or to the circumstances of the release. Compliance is required at the completion of the remedial action for hazardous substances, pollutants, or contaminants that remain on site.

The three classifications of potential ARARs are chemical specific, action specific, and location specific which are addressed, respectively, in Sections 3.3.1, 3.3.2, and 3.3.3. "To be considered" criteria (TBCs) are included with the ARARs for each classification.

3.3.1 Chemical Specific ARARs

Chemical specific requirements are used to set concentration limits or discharge limitations in various media for specific hazardous substances, pollutants, or contaminants. Appendix A contains potential chemical specific ARARs and TBCs for water including the final maximum contaminant levels (MCLs) for drinking water, proposed MCLs, maximum contaminant level goals (MCLGs), secondary MCLs, ambient water quality criteria (AWQC) for surface water, and health advisories for drinking water. However, EPA may establish site specific exposure-based alternate concentration limits (ACLs) where the ground water cannot be used for drinking because of naturally occurring widespread contamination or where cleanup is not practicable and where the circumstances fulfill the conditions of CERCLA Section 121(d)(B)(ii) (U.S. EPA, 1988: CERCLA Compliance with Other Laws Manual at page xviii).

3.3.2 Action-Specific ARARs

Action-specific requirements generally set performance, design, or other similar controls or restrictions on particular activities related to management of hazardous substances or pollutants. An example of an action-specific requirement is the performance standards for incineration of hazardous waste in RCRA Section 264.343. RCRA provides the largest number of action-specific requirements because it is the statute directed toward hazardous waste management. Potential action-specific requirements for Buckeye Reclamation Landfill are contained in Appendix A. These action-specific requirements do not determine the remedial alternative but do determine how a selected alternative must be achieved.

3.3.3 Location-Specific ARARs

Location-specific requirements are design requirements or activity restrictions based on the geographical or physical position of the site and its surrounding area. Location-specific requirements might come from RCRA location requirements, 40 CFR Part 6 Subpart A, that set U.S. EPA policy for carrying out provisions of Executive Orders 11988 (Flood Plain Management) and 11990 (Protection of Wetlands). Potential location-specific requirements for Buckeye Reclamation Landfill are contained in Appendix A.

3.4 <u>Remediation Objectives</u>

Remediation objectives for the BRL site address the site problems discussed in Section 3.2. Consistent with the general remedial objectives for CERCLA actions, the media-specific response actions are intended to mitigate possible threats to human health and the environment which were characterized in the RI and EA. As noted in Section 3.2, existing or potential threats to public health and the environment exist for ground water which emerges as surface water, and contact with surface and subsurface soils to which the public might be exposed. The media-specific remediation objectives are presented and discussed below.

3.4.1 Ground Water

3.4.1.1 On Site

Response actions for site water-bearing zones are intended to maintain and/or attain acceptable concentrations of contaminants emanating from the Waste Pit or the general landfill in the ground water and eventually discharging to surface water. This objective can be achieved by permanently immobilizing contaminants in the Waste Pit and fill area via minimizing recharge to ground water, and by controlling discharge of ground water to surface water.

3.4.1.2 Off Site

Response actions for off-site ground water, specifically the domestic wells downgradient of the site and Howard Spring, are linked to those for on-site ground water in that by controlling releases of ground water to on-site surface waters, the possibility of contamination in the domestic wells near the site by contaminants emanating from the site will be significantly reduced or eliminated.

3.4.2 Surface Water

Response actions for Kings Run are intended to maintain and or attain acceptable concentrations of contaminants attributable to the Waste Pit or general landfill in the water. thereby restoring the surface water to a useful, less threatening state by reducing the levels of contaminants present. This objective is linked to those for on-site ground water and leachate seeps (below) in that by controlling releases to surface water from the landfill, contaminant levels in surface water will be reduced.

3.4.3 Leachate Seeps

Response actions for site leachate seeps are intended to attain acceptable concentrations of contaminants attributable to the Waste Pit or general landfill entering surface water. This can be achieved via containment measures (e.g., capping), which minimize leachate generation by controlling water infiltration, and by collection and treatment of the existing surface leachates until they dry as a result of capping and reduction of recharge.

3.4.4 Soils

3.4.4.1 Waste Pit

Response actions for the Waste Pit soils contaminated at a depth of 12 feet and below are intended to permanently immobilize contaminants contained in the pit via containment measures, which would eventually lower the water table below the pit, or source elimination (i.e., excavation and treatment of solids). These actions would also significantly reduce or eliminate the possibility of contaminants entering the ground water and hence to surface water, and in leachate seeps.

3.4.4.2 Landfill Soils

For soils in the general municipal landfill area, response actions are intended to provide protection to public health and the environment by limiting direct physical contact with the surficial soils thus reducing risks due to dermal contact, inhalation, and ingestion, and to immobilize contaminants contained in the landfill via containment measures. EPA de-emphasizes remedies involving treatment of large municipal landfills, which generally have large volumes of low concentration wastes, because treatment may be prohibitively expensive or difficult to implement (EPA, 1988). Therefore, these two remediation objectives can be accomplished effectively by containment (capping).

4.0 DEVELOPMENT GENERAL RESPONSE ACTIONS

General response actions are medium-specific groups of remedies which are assembled to meet the remedial action objectives at the site. The general response actions for the Buckeye Reclamation site, along with the remedial technologies which compose the response actions, are developed and listed separately for the soil and water matrices below.

The remedial objective for the soil is the protection of public health and the environment by limiting contact with the contaminated soil. General response actions were developed primarily to limit direct contact with the contaminated soil. In addition, the general response actions and technology types for the soil are developed to assist in meeting the remedial action objectives for ground water and surface water. Other contaminants in the soil (e.g., metals and acidic leachate) may act as a source for future surface water contamination.

The remedial action objective for surface water is the protection of public health and the environment by remediating contaminated surface water. This can be accomplished by developing and utilizing general response actions that control or eliminate surface runoff, surface leachates, and ground water entering surface water. At the BRL site, the general response actions and technology types intended to achieve the remedial objectives are linked in that implementation of one technology type for one medium will contribute to remediation of another medium.

These response actions are presented in greater detail in Table 4-1 for each environmental medium and remedial objective.

TABLE 4-1
Summary of General Response Actions for the Buckeye Reclamation Landfill Site

ENVIRONMENTAL MEDIUM	REMEDIAL OBJECTIVES	GENERAL RESPONSE ACTIONS	TECHNOLOGY TYPE	COMMENTS
GROUND WATER				
• On Site	None	No Action/Institutional Actions/Monitoring	No Action/Institutional Options • Fencing • Deed Restrictions • Sampling and Analysis	Provides baseline for comparison to all remedial actions as required by the NCP. Monitoring of the site for 30 years following implementation of remedial actions required in all alternatives.
	Minimize discharge of contaminated ground water to surface	Containment	Capping Vertical Barriers Horizontal Barriers Gradient Control	Prevents recharge to water bearing zones, thereby reducing water levels in the zones, or prevents migration of ground water to surface water.
		Collect and Treat or Discharge	Extraction Wells Drains Treatment/Disposal • On Site -Biological -Physical/Chemical -Thermal Destruction -Discharge • Off-Site -POTW -RCRA Facility	Collect ground water discharging to surface water and provide on site or off site treatment and disposal.

TABLE 4-1
Summary of General Response Actions for the Buckeye Reclamation Landfill Site
(Continued)

ENVIRONMENTAL MEDIUM	REMEDIAL OBJECTIVES	GENERAL RESPONSE ACTIONS	TECHNOLOGY TYPE	COMMENTS
	Maintain or attain acceptable concentrations of contaminants in the site ground water.	In Situ Treatment	Biological Physical/Chemical	Inject treatment chemicals or agents into the water to effect treatment
• Off Site				
Residential Wells	None	No Action/Institutional Actions/Monitoring	No Action/Institutional Options • Deed Restrictions • Sampling and Analysis	Provides baseline for comparison to all remedial actions as required by the NCP. Monitoring of neaby residential wells required for 30 years following remedial action
	Prevent future contamination of nearby residential wells	Actions to reduce control or prevent contamination from on site ground water and surface leachates to surface water	On site ground water technologies above	The remedial objective for nearby off site residential wells will be accomplished by on site ground water remediation. The residential wells do not pose a current risk
SURFACE WATER				
-Leachate Seeps	None	No Action/Institutional Action/Monitoring	No Action/Institutional Options • Fencing • Deed Restrictions • Sampling and Analysis	Provides baseline for comparison to all remedial actions as required by the NCP. Monitoring of any surficial leachates required following remedial action

TABLE 4-1
Summary of General Response Actions for the Buckeye Reclamation Landfill Site
(Continued)

ENVIRONMENTAL MEDIUM	REMEDIAL OBJECTIVES	GENERAL RESPONSE ACTIONS	TECHNOLOGY TYPE	COMMENTS
	Minimize or eliminate discharge of surface leachates to surface waters	Containment and Collection/Treatment/Disposal or Discharge	Capping Drains Teatment/Disposal • On Site -Biological -Physical Chemical Thermal Destruction Discharge • Off Site POTW -RCRA Facility	Prevents recharge to shallow soils, thereby reducing leachate generation. Control on discharges of leachate provided until containment stops leachate generatin
Kings Run	None	No Action/Institutional Action/Monitoring	No Action/Institutional Options • Fencing • Deed Restrictions • Sampling and Analysis	Provides baseline for comparison to all remedial actions as required by the NCP. Monitoring of surface water required following remedial actions
	Restore surface water to a useful, less threatening condition by minimizing contamination of Kings Run from surface runoff and from ground water and leachates.	Containment	Containment actions to reduce, control, or prevent contamination by on site ground water and surface leachates	The remedial objectives for Kings Run can be accomplished by on site ground water and leachate remediation discussed above, and by soil remedial actions discussed below

TABLE 4-1
Summary of General Response Actions for the Buckeye Reclamation Landfill Site
(Continued)

ENVIRONMENTAL MEDIUM	REMEDIAL OBJECTIVES	GENERAL RESPONSE ACTIONS	TECHNOLOGY TYPE	COMMENTS
	Restore surface water to a useful, less threatening condition by reducing contaminant concentrations in Kings Run	Collection/Treatment/ Disposal	Treatment/Disposal • On Site Biological Physical/Chemical Thermal Destruction • Off Site POTW RCRA Facility	The remedial objectives for Kings Run can be accomplished also by direct treatment of surface water
SOILS				
Waste Pit	None	No Action/Institutional Actions	No Action/Institutional Options • Fencing • Deed Restrictions	Provides baseline for comparison to all remedial actions required by the NCP
	Reduce mobility of contaminants from Waste Pit soils	Containment	Capping	Eliminates recharge to the Waste Pit, thereby decreasing water table elevation and eliminating exposure of Waste Pit soils to ground water
	Reduce mobility, toxicity, or volume of contaminated soil in	Excavation/On Site Treatment	Biological Treatment Physical/Chemical Treatment Thermal Destruction	Includes both on site treatment in plants and in situ treatment methods
		Excavation/Off Site Treatment	Biological Thermal Destruction	Off site treatment may include methods used for on site treatment, except for in situ methods

TABLE 4-1

Summary of General Response Actions for the Buckeye Reclamation Landfill Site

(Continued)

ENVIRONMENTAL MEDIUM	REMEDIAL OBJECTIVES	GENERAL RESPONSE ACTIONS	TECHNOLOGY TYPE	COMMENTS
Landfill Soils (Surficial)	None	No Action/Institutional Actions	No Action/Institutional Options •Fencing •Deed Restrictions	Provides baseline for comparison to all remedial actions as required by the NCP
	Minimize direct contact with exposed mine spoil and garbage, and minimize or eliminate potential for soils to contaminate ground water	Containment	Capping	Provides barrier to direct contact exposure with contaminated surficial soils and also reduce recharge thus minimizing or eliminating the potential for landfill contaminants to contaminate ground water and leachates

5.0 SCREEN GENERAL RESPONSE ACTIONS REMEDIAL TECHNOLOGIES

5.1 Introduction

The objectives of the technology screening process are to eliminate the infeasible technologies and process options from the master list of General Response Actions presented in Table 4-1, and to select the most viable process option from each technology group, if possible. The selected process options will then be combined to form potential remedial alternatives for the site.

The screening and evaluation of process options was performed in two phases. The first phase consisted of identifying the universe of potentially applicable process options and technology types, and evaluating these options with respect to technical implementability. During this screening phase, options were evaluated based on site characteristics, contaminant types and concentrations, and technology constraints. Those options that could not be effectively implemented at the site were screened out from further evaluation.

The second phase consisted of further evaluating the options that were considered to be implementable based on the first evaluation and screening phase. Within each technology type, the effectiveness, cost, and implementability of the options were further evaluated and compared to one another. Emphasis was placed on the effectiveness of the options. Where possible, one representative option was selected for further evaluation from each technology type. In addition, technology types within a general response action were compared to each other.

The following sections present the screening and evaluation of process options for each media (i.e., ground water, surface water, surface leachate seeps, and soils) at the BRL site. For each media, the scope of remediation, phase one screening and phase two screening are discussed. The technology evaluation for the surface leachate seeps includes a more detailed discussion of treatment options for combined leachate and ground-water flows.

5.2 Ground Water

5.2.1 Scope of Remediation

Ground water at the site moves downgradient to the southeast, eventually discharging into Kings Run. Remediation involves measures to reduce infiltration to ground water, measures to extract and treat ground water, and/or measures to intercept and treat ground water before it discharges into Kings Run.

5.2.2 Phase One Screening

Remedial technologies and process options identified for the general response actions for ground-water remediation are presented in Table 5-1. During phase one of the screening process, these technologies and options were screened with respect to their implementability at the BRL site. Most of the technologies and options initially identified were eliminated from further consideration because site conditions, such as fractured bedrock water-bearing zones, low hydraulic conductivity in the bedrock water-bearing zones, and the heterogeneity of the mine spoil water-bearing zone, limited the feasibility of collection and in situ treatment of ground water. Control on the discharge of ground water to surface water can be implemented by collection drains along Kings Run, however. Table 5-2 summarizes those remedial technologies and process options remaining after the phase one screening was completed.

5.2.3 Phase Two Screening

The ground-water remedial technologies and process options remaining after the phase one screening were evaluated in greater detail during phase two screening. These technologies and options were screened with respect to their effectiveness, implementability, and cost relative to other process options within the same technology type, with emphasis on effectiveness, as shown on Table 5-3. Cost was used as a screening criterion only if process options within a technology type had equivalent degrees of effectiveness and implementability. Based on this screening, deed restrictions, on-site and off-site ground-water monitoring, containment by capping, and collection by subsurface drains remained as potentially applicable process options, as shown on Table 5-4.

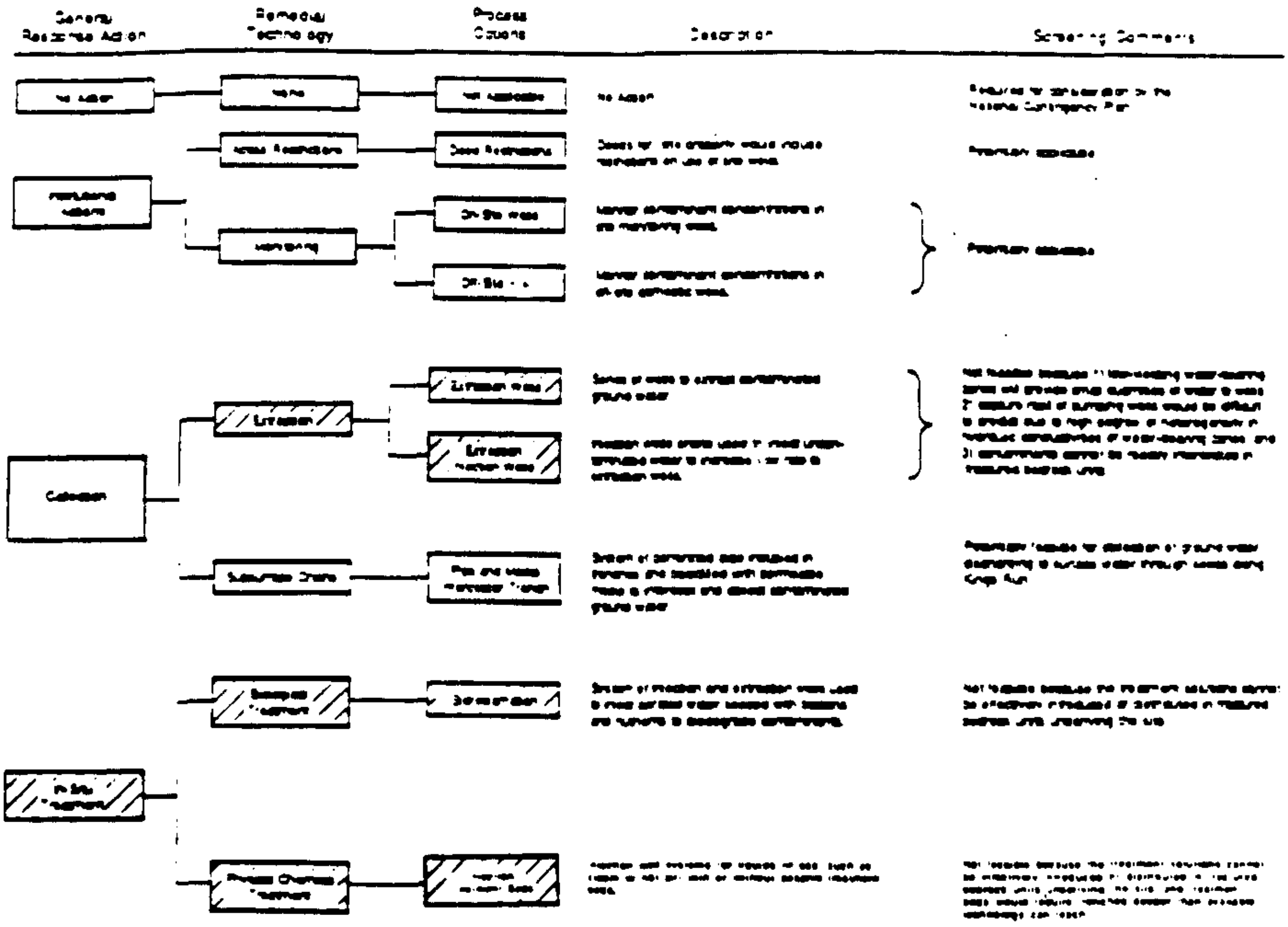
5.3 Surface Water

Along its course, Kings Run receives discharges of ground water from the landfill area, leachates from surface seeps, and runoff from the general landfill during storms.

The Endangerment Assessment for the site showed that Kings Run surface water posed a potential future risk to human health by ingestion but the pre-landfill condition, represented by the upstream sampling station on Kings Run, did not pose a significant risk. Therefore, contamination of Kings Run to levels posing significant risk is caused by discharges from the site through the pathways noted above.

Remediation of ground-water discharges to surface water is discussed in Section 5.2, coupled with remediation of surface leachate seeps (Section 5.4) and remediation of the surficial soils (Section 5.5) that contribute contaminants will achieve the remedial objective for surface water in Kings Run. No separate remediation of Kings Run is required.

TABLE 5-1. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR SITE GROUND WATER



*Note: Additional hydrogeologic information gathered during pre-design studies may determine that extraction wells or other ground-water collection technologies are necessary for collection of contaminated ground water.

TABLE 5-1. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR SITE GROUND WATER (Continued)

General Response Action	Remedial Technology	Process Options	Description	Screening Comments
Containment	Vertical Barriers	Slurry Wall	A subsurface barrier that reduces or restricts the flow of ground water, constructed by excavating a trench and filling it with a slurry of bentonite clay and water, and then backfilling the trench with soil and/or slurry.	Not feasible because 1) water table depths would require deep trenching through rock for the 5 deepest water bearing zones, and 2) trenching through a minimum of 30 feet of nonhomogeneous material.
		Grout Curtain	Specified fluids are pressure injected into a rock or soil body, where it sets into the rock or soil voids, greatly decreasing the permeability and increasing strength of the grouted mass.	Not feasible because fluids cannot be effectively introduced or distributed in fractured bedrock units underlying the site.
		Sheet Piling	Interlocking piles made of steel, wood, or concrete and driven into the ground or pushed into pre-dug trenches to form a continuous groundwater barrier.	Not feasible because 1) water table depths would require deep trenching through rock for the 5 deepest water bearing zones, and 2) trenching through a minimum of 30 feet of nonhomogeneous material.
		Vibrating Beam	Steel beams are pneumatically driven into the ground and the excavations filled with grout as the beams are withdrawn.	Not feasible because 1) water table depths would require deep trenching through rock for the 5 deepest water bearing zones, and 2) trenching through a minimum of 30 feet of nonhomogeneous material.
	Horizontal Barriers	Block Displacement	Used in conjunction with vertical barriers, slurry is injected into notched holes to produce a horizontal barrier beneath the site.	Not feasible because the slurry cannot be effectively introduced or distributed in fractured bedrock units underlying the site.
		Grout Injection	Pressure injection of grout at depth through closely-spaced drilled holes.	
	Capping	RCRA Cap	Installation of caps of various designs over the landfill and surrounding areas intended to reduce recharge to landfill and Waste Pit, thus immobilizing the contaminants. Full thickness of cap may not be needed in some areas.	All these types of caps are feasible although the RCRA cap will be extremely expensive to install due to the need for extensive excavation to achieve required slopes. Lesser thickness of caps may be satisfactory to meet ARARs outside of landfill area.
		Standard Solid Waste Landfill Cap		
	Gradient Control	Wells	A series of wells pumping ground water to reverse a flow direction and prevent contaminant migration.	Not feasible due to low-yielding formations, other saturated zones and fractured rock.
		Subsurface Drains	System of perforated pipe installed to intercept ground water and prevent contaminant migration.	Potentially feasible to control discharge of ground water to surface water [illegible]

LEGEND
▨ — Process options and technologies that have been screened out
☐ — Process options and technologies that are potentially applicable

TABLE 5-2 SUMMARY OF PROCESS OPTIONS REMAINING AFTER PHASE ONE SCREENING FOR GROUND WATER

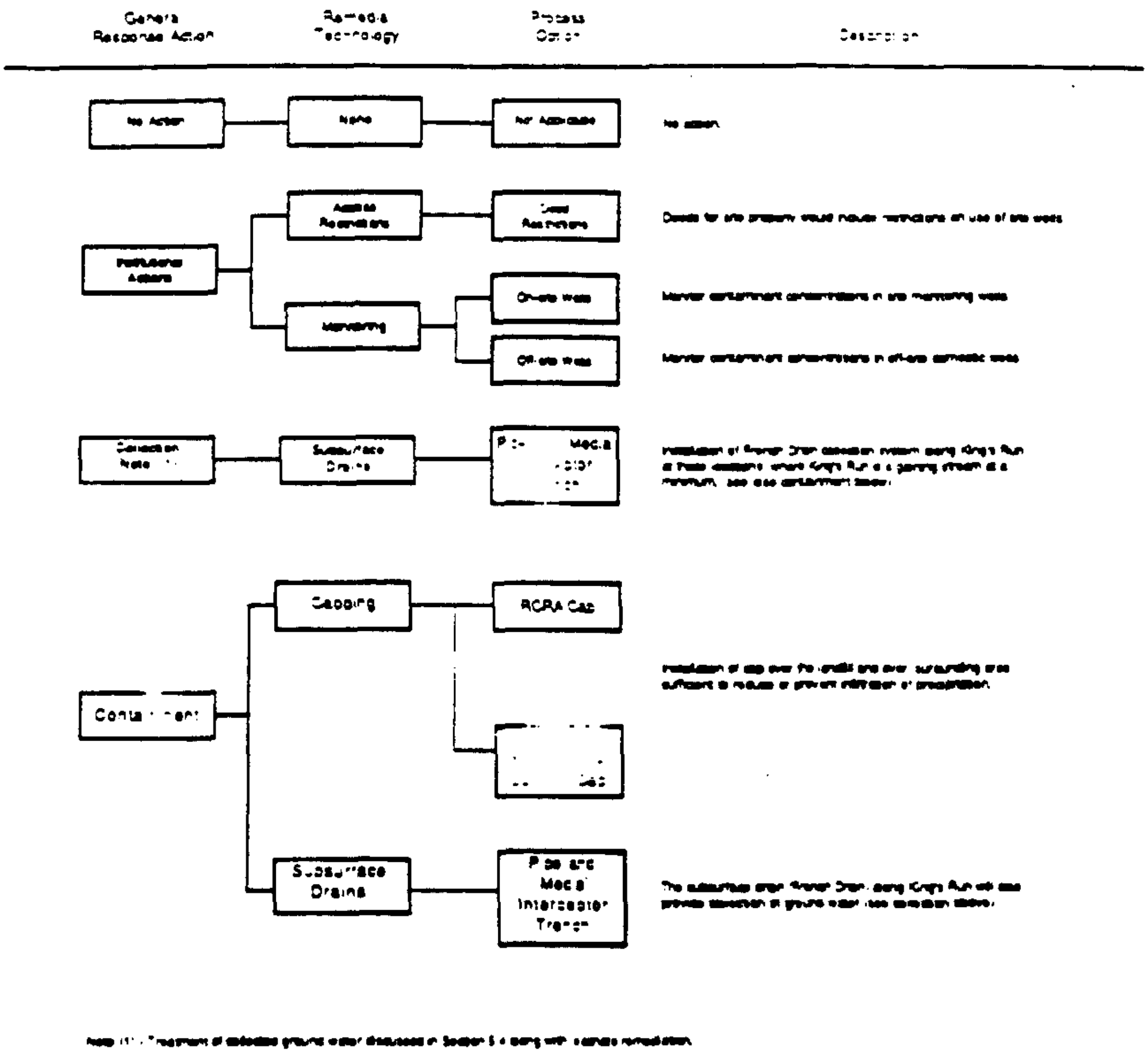


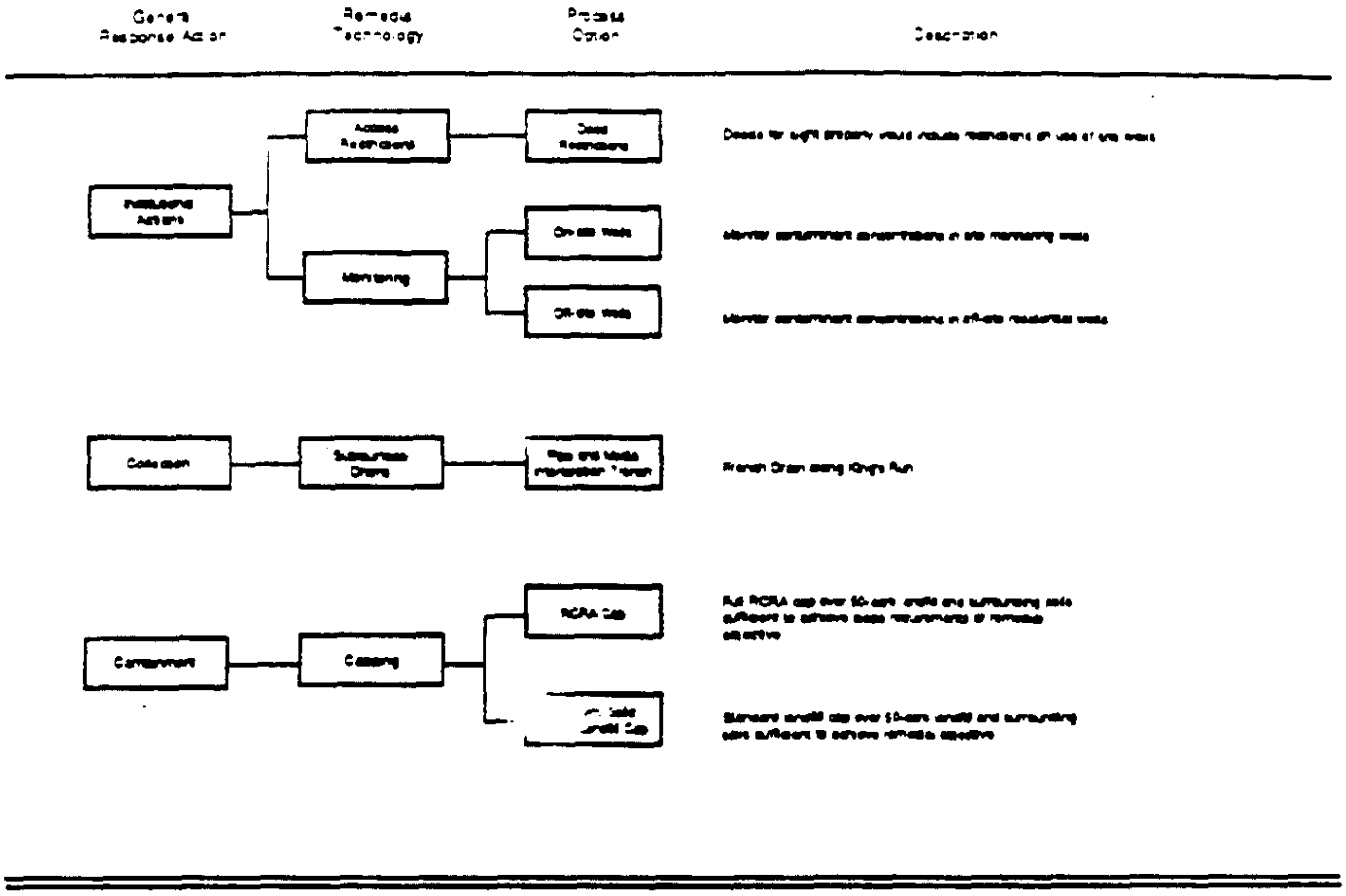
TABLE 5-3. PHASE TWO SCREENING OF PROCESS OPTIONS FOR SITE GROUND WATER

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
No Action	None	Not Applicable	Does not achieve remedial action objectives. Considered as required by the NCP	Not acceptable to local/public government	None
Institutional Actions	Access Restrictions	Deed Restrictions	Effectiveness depends on future site usage. Does not reduce contamination. Reduces direct contact risk by restricting receptors	Contaminants remain on site. Easily implemented	Negligible cost
	Monitoring	On site Wells; Off site Wells	Effective indicator of potential risk. Does not reduce contamination. Effectively monitors response actions implemented for other media	Moderately easy to implement. Use of existing wells is applicable	Low capital cost. Low O&M cost
Collection	Subsurface Drains	Pipe and Media Interceptor Trench	Effective at intercepting ground water before it discharges to surface water	Easily implemented along Kings Run	Moderate capital cost low O&M cost
Containment	Capping	RCRA Cap	Highly effective at achieving remedial objective	Difficult to implement due to high relief at site	High capital cost low to moderate O & M cost
		Standard Solid Waste Landfill Cap	Highly effective at achieving remedial objective	Easily implemented. Restrictions on future land use required	Moderately low capital cost low O & M cost
	Subsurface Drains (screened out)	Pipe and Media Interceptor Trench (screened out)	Screened out as duplication of identical technology for collection (see above)		

LEGEND

▨	Process options and technologies that have been screened out
☐	Process options and technologies that are potentially applicable

TABLE 5-4. SUMMARY OF PROCESS OPTIONS REMAINING AFTER PHASE TWO SCREENING FOR GROUND WATER



5.4 Surface Leachate Seeps

5.4.1 Scope of Remediation

Surface leachate seeps discharge from the site into Kings Run either directly or during storm runoff events. In order to achieve the remedial objective for surface water, leachate seeps must be controlled at least until other measures such as capping and ground-water collection (Section 5.2) successfully dewater the site causing the surface leachate seeps to dry.

The leachates sampled during the Remedial Investigation that require remediation are L-1 and L-2 located in the vicinity of the Waste Pit, L-5 located north of the landfill draining into the impoundment, and L-4 located at the southern toe of the landfill. Leachate seeps L-3 and L-6 do not originate from the landfill and do not discharge into Kings Run and, therefore, do not affect the quality of Kings Run during either baseflow or stormflow. It should be noted that L-5 is considered to be representative of pre-landfill conditions at the site; nevertheless, control on the discharge of L-5 is needed to achieve the remedial objective for Kings Run. Other site-derived leachate seeps that may be discovered during remedial design/remedial action (RD/RA) will also be remediated.

The primary constituents of concern are heavy metals, to a lesser extent, volatile organic compounds present in leachates L-1 and L-2, and low pH. These surface leachate seeps are the most significant of the known seeps at the site and form the basis for evaluation and costing of remediation for this medium. Provisions for control of new seeps, should they occur, will be addressed during design.

5.4.2 Phase One Screening

The general response actions selected for surface leachate seeps are (1) no action, (2) institutional actions, and (3) collection, treatment, and discharge. Remedial technologies and process options for these general response actions were identified and evaluated with respect to technical implementability. Table 5-5 summarizes the screening of leachate process options for the BRL site.

The "no action" option was considered as required by the National Contingency Plan (NCP). However, the "no action" option does not attain the remedial action objective for surface water.

As "institutional actions", access restrictions include deed restrictions to the property to limit or eliminate possible use or development of the site, and fencing around the leachate generation points and pathways. Monitoring involves measuring contaminants of concern or water quality parameters.

TABLE 5-5. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR SURFACE LEACHATE SEEPS

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	None	None	No action	Required for consideration by the National Contingency Plan
Institutional Actions	Access Restrictions	Deed Restrictions	Deeds for site-property would restrict possible site uses and development.	Potentially applicable to limit future exposure to leachates and surface water
		Fencing	Install security fencing around leachate seeps	
	Monitoring	Leachate Monitoring	Monitor contaminant concentrations and/or water quality parameters (e.g., pH, COD, BOD, TOC)	Potentially applicable as a means of assessing changing levels of contamination
	Leachate Collection	Holding Basin	Leachates are collected in a lined holding basin or wetland area.	Potentially applicable
		Storage Tank	Leachates are collected in a storage tank.	Volume could be too large to be a feasible option
	Chemical Treatment	Reduction	A reducing agent is added to reduce heavy metals (e.g., chromium) before precipitation	Not applicable because contaminants (e.g., iron, manganese) are in a reduced state
		Oxidation	An oxidant (e.g., air) is added into the solution to oxidize heavy metals before removal and/or to oxidize VOCs	Not applicable for the removal of heavy metals in leachates but applicable as a pretreatment of Mn and Fe before precipitation
		Precipitation	A chemical (such as lime, ferric sulfate, alum, sodium carbonate) is added into the solution to precipitate the heavy metals at an elevated pH	Potentially applicable for the removal of heavy metals in leachates. Not applicable for the removal of organic chemicals
		Neutralization pH Adjustment	The pH of the solution is adjusted (by acid or base addition) to meet other treatment requirements (e.g., oxidation, biological treatment) and/or discharge requirements	Potentially applicable as a pretreatment for subsequent removal processes (e.g., precipitation, biological treatment, ion exchange, carbon adsorption) and to meet discharge requirements. Not applicable as a stand alone treatment for heavy metals or organics in leachates
		Ion Exchange	Ions of contaminants in the solution are exchanged with the ions in the ion exchange resin. The exhausted resin is either disposed of or regenerated	Potentially applicable to all heavy metal contaminants in the leachate. Potentially applicable to some organic contaminants in the leachates

LEGEND

- Process options and technologies that have been screened out
- Process options and technologies that are potentially applicable

TABLE 5-5. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR SURFACE LEACHATES SEEPS (Continued)

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Collection / Treatment / Discharge	Physical Treatment	Settling	Suspended or precipitated solids are settled by gravity with or without addition of a flocculant.	Not applicable as a stand-alone treatment of leachates. Potentially applicable as a post-treatment for precipitation and pretreatment for ion exchange or air stripping. Not applicable for organic contaminants or dissolved solids.
		Oil/Water Separation	Water-miscible and water-immiscible phases are separated by gravity settling.	Not applicable. All leachates are one-phase systems.
		Air Stripping	Volatile organic contaminants (VOCs) are transferred from the water phase to the air phase using air as the stripping agent.	Not applicable for the removal of heavy metals.
		Steam Stripping	Volatile and semivolatile organic contaminants are transferred from the water phase to the air phase using steam as the stripping agent.	Not applicable for removal of heavy metals.
		Carbon Adsorption	Certain dissolved organic and inorganic contaminants in water are adsorbed into activated carbon particles. Used carbon is either regenerated or disposed of as hazardous waste.	Not applicable for all heavy metal treatment.
		Liquid-Liquid Extraction	Dissolved organic contaminants in water are extracted by a solvent, which preferentially dissolves these contaminants. The solvent must be immiscible in water and differ in density.	Not applicable for removal of heavy metals.
		Reverse Osmosis	Contaminated water is forced through a semi-permeable barrier (membrane) under high pressure (200 to 1,200 psi) to pass through only certain contaminants. The highly concentrated reject stream must be further treated or disposed of.	Potentially applicable for removal of all contaminants.
	Biological Treatment	Wetlands	Contaminated water treated by adsorption, neutralization and precipitation in a constructed wetland.	This technology is widely used by the mining industry to remediate acid mine drainage.
		Aerobic Biological Treatment	Organic contaminants are mineralized in an aerobic environment (e.g., in the presence of oxygen) into oxidized forms. Processes include activated sludge, powdered activated carbon treatment (PACT), trickling filter, and rotating biological contactors (RBC).	Potentially applicable for the removal of Pb and Hg with biomass. Not applicable for the removal of other metals.
		Anaerobic Biological Treatment	Organic compounds are biologically degraded anaerobically (in the absence of oxygen) to methane and carbon dioxide. Anaerobic processes include anaerobic filter and upflow anaerobic sludge blanket.	Not applicable for the removal of heavy metals.
	Offsite Treatment	POTW	Untreated or partially treated leachates are transported by tank trucks to POTW for further treatment.	The local POTW is a considerable distance away and questionable whether it could adequately treat the waste water.
		RCRA Facility	Untreated or partially treated leachates are transported by tank trucks to a licensed RCRA facility for further treatment.	The nearest RCRA facility is a considerable distance away. Extensive bulk transfer required.
	Onsite Discharge	Onsite Stream (Kings Run)	Treated leachates are discharged to a site stream (e.g., Kings Run).	Potentially applicable.
		Onsite Injection	Treated leachates are injected into deep wells constructed on site.	Not feasible because of leaching potential of contaminants into ground water.
	Offsite Discharge	Off-site River After Onsite Treatment	Leachates are treated onsite and discharged to an off-site river (e.g., Little McMahon Creek).	Potentially applicable.
		Off-site Water Body After Off-site Treatment	Leachates treated off site are discharged to an off-site water body.	No suitable off-site water body located nearby.

LEGEND

(hatched box)	— Process options and technologies that have been screened out
(open box)	— Process options and technologies that are potentially applicable

Under the "collection, treatment, and discharge" general response action, various collection, treatment, and discharge options were considered. Only holding basins were found to be technically feasible. For the treatment of these leachates, on-site chemical, physical, and biological process options as well as off-site treatment options were considered.

Among the on-site chemical processes evaluated were reduction, oxidation, precipitation, neutralization, and ion exchange processes. Reduction was eliminated from further consideration because the polyvalent heavy metal contaminants would already be in a reduced state at the pH of the leachates (i.e., iron is expected to be present as ferrous ion, and manganese is expected to be present as manganous ion). Oxidation was eliminated from further consideration, because it is not applicable for the treatment of heavy metals. Neutralization (pH adjustment) and precipitation are retained as potentially applicable processes, used together, for removal of heavy metals from leachates and ground water.

Ion exchange involves passing the contaminated solution through a bed of resin to exchange the heavy metal ions in the solutions with the ions in the resin bed. Strong anion exchange resins have been found to be applicable for the treatment of heavy metals. In addition, the ion exchange process may be applicable for the treatment of some organic contaminants.

Among the on-site physical treatment processes evaluated, oil/water separation process was eliminated because the waste stream is a single aqueous phase; the liquid-liquid extraction was eliminated because it is not effective for removal of heavy metals; and settling was eliminated as an independent process because it is not applicable as a stand-alone process for the removal of heavy metals. However, settling may be considered as a post-treatment process associated with heavy metal precipitation (for the separation of heavy metal precipitates from the supernatant liquid). Air stripping, steam stripping, and carbon adsorption processes were eliminated as not applicable to removal of heavy metals. Reverse osmosis is potentially applicable for removal of heavy metals and some organics.

For the on-site biological treatment processes, aerobic and anaerobic treatments are not applicable to heavy metals removal and were rejected. Wetlands have been used successfully by the mining industry to remove heavy metals by precipitation, settling, and adsorption; this process option was retained.

POTW and RCRA facilities were considered for off-site treatment but were rejected due to the fact that large volumes of water would have to be transported tens to hundreds of miles to implement this option.

For the discharge of the treated leachates and ground water, the on-site discharge options evaluated include discharge to the local stream (i.e., Kings Run), and on-site injection. Discharge to Kings Run is potentially applicable, but on-site injection of the treated water is contrary to this general remedial objective of dewatering the landfill. Piping of the treated leachate to the Little McMahon Creek is potentially applicable if the leachates are treated on site. Discharge of the leachate to a surface body after treatment was rejected as no suitable water body is located within a reasonable distance from the site.

A summary of the process options remaining after phase one screening is presented in Table 5-6.

5.4.3 Phase Two Screening

To develop remedial alternatives, the process options were evaluated in greater detail before selecting one or a few processes to represent each technology type. This evaluation was performed using effectiveness, implementability, and cost as criteria. The analysis is presented in Table 5-7 and discussed below.

Collection by a storage basin is retained in the collection, treatment, and discharge response action. Collection of leachates (and ground water) in a holding basin or wetland is effective, implementable at the site, and relatively low cost.

In comparing chemical treatment options between chemical precipitation and ion exchange processes, the chemical precipitation process is more effective for the treatment of concentrated heavy metals solutions than the ion exchange process and at a lower cost.

Implementation of the reverse osmosis process at the BRL site would prove to be difficult and expensive because leachates contain high concentrations of cations and anions as well as organics, which may frequently foul the membrane. The reverse osmosis process, if implemented, would also generate more concentrated solutions possibly requiring further treatment before disposal or off-site disposal at a RCRA facility. Furthermore, this process has high capital and O&M costs compared to chemical treatment processes of equal effectiveness. Reverse osmosis was eliminated from further consideration.

Wetland treatment should prove to be effective, relatively easily implemented, and of moderate cost assuming sufficient land area of low slope can be obtained.

For the disposal of the treated leachates at the site, discharge to Little McMahon Creek is more readily implementable and most cost effective since all discharge could be gravity fed. Discharge to Kings Run would probably require a more costly pipeline and lift station.

TABLE 5-6 SUMMARY OF PROCESS OPTIONS REMAINING AFTER PHASE ONE SCREENING FOR SURFACE LEACHATE SEEPS (AND GROUND WATER)

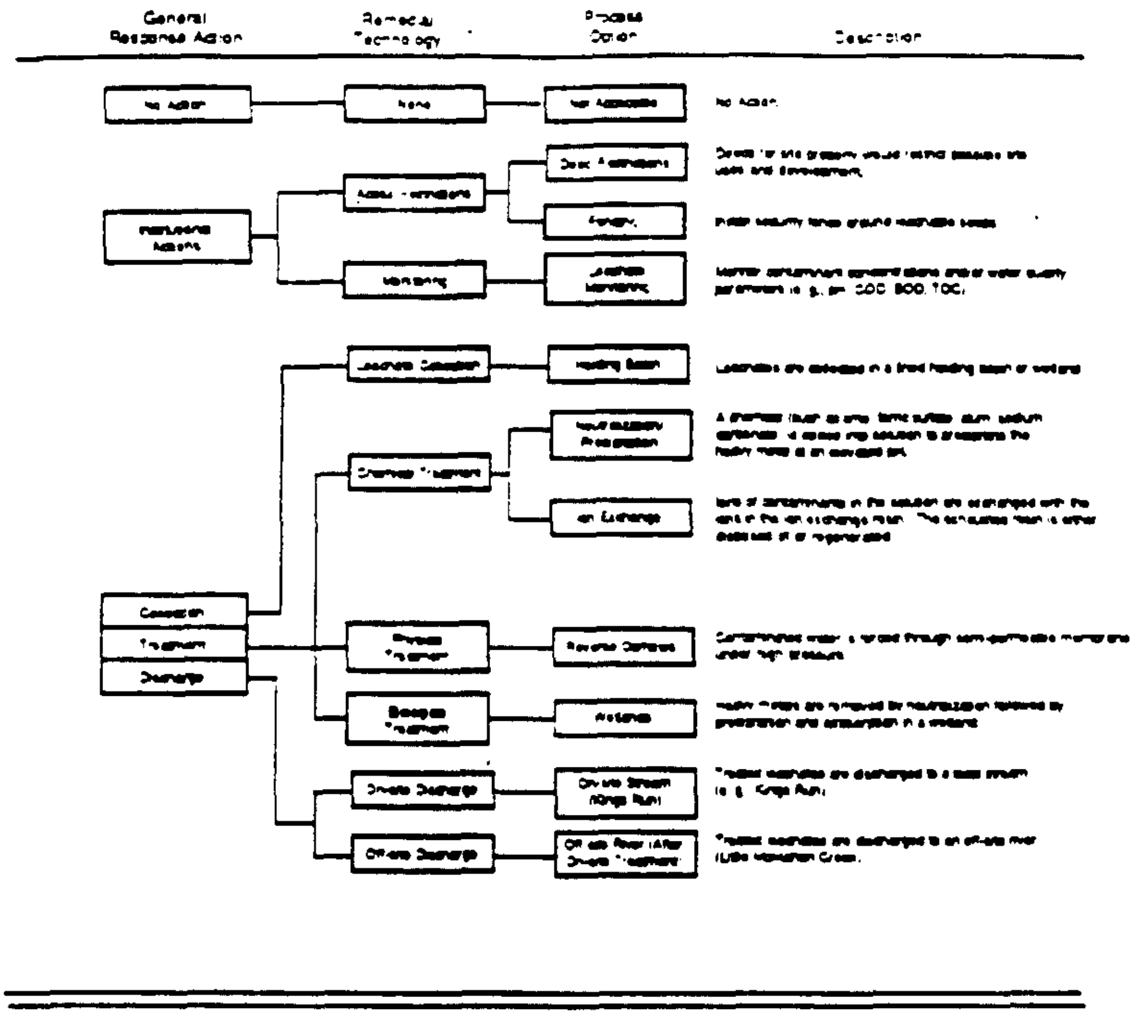


TABLE 5-7. PHASE TWO SCREENING OF PROCESS OPTIONS FOR SURFACE LEACHATE SEEPS (AND GROUND WATER)

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
No Action	None	Not Applicable	Does not achieve remedial action objectives. Required to be considered by NCP	Not acceptable to local/public government	None
Institutional Actions	Access Restrictions	Deed Restrictions	Does not reduce contamination, but reduces risk from direct exposure	Legal requirements and authority	Negligible cost
		Fencing	Does not reduce contamination, but reduces risk from direct exposure	Readily implementable	Negligible capital
	Monitoring	Leachate Monitoring	Useful for documenting conditions. Does not reduce contamination, but [illegible] is necessary	Alone, not acceptable to local/public government	Low O&M
Collection / Treatment / Discharge	Leachate Collection	Holding Basin	Effective, especially as a wetland	Requires lining. Susceptible to rain water	Low capital cost
	Chemical Treatment	Neutralization/ Precipitation	Precipitation by lime is effective in the treatment of heavy metals in leachate more than any other precipitation chemical. Lime precipitation is effective for the treatment of Ba, Fe, Mn, and Pb. Following precipitation, settling (with/without addition of flocculant/coagulant) removes suspended solids and heavy metal precipitates	Implementable with operator assistance	High capital, moderate to high O&M
		Ion Exchange	Effective as a polishing treatment for all heavy metals except for iron. Potentially effective for organics. Requires pretreatment (removal of suspended solids, high concentrations of heavy metal, pH adjustment). Must be used with other treatment technologies	Implementable with some operator assistance. Exhausted resin must either be regenerated or disposed. Regeneration requires treatment and/or handling of regenerate	High capital, high O&M

LEGEND

- (hatched box) – Process options and technologies that have been screened out
- (open box) – Process options and technologies that are potentially applicable

TABLE 5-7. PHASE TWO SCREENING OF PROCESS OPTI[illegible]OR SURFACE LEACHATE SEEPS (AND GROUND WATER) (Continued)

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
	Physical Treatment	Reverse Osmosis	Effective for the removal of all dissolved solids and potentially effective for organic contaminants. Does not eliminate contamination, but generates a concentrated solution, which requires further treatment before disposal	Difficult to implement because of the potential for membrane fouling [illegible]. Some operator assistance is required	High capital, high O&M
	Biological Treatment	Wetland	Effective for removal of metals	Small wetland possible on the site	Low capital, low O&M
	On Site Discharge	On site Stream (Mingo Run)	Effective and reliable. Duplicative of off site discharge at potentially greater cost	Implementation may require a lift station. NPDES Permit required	Moderate capital, low O&M
	Off Site Discharge	Off site River (After On site Treatment)	Effective and reliable	Easily implemented by gravity discharge. NPDES Permit required	Low capital, low O&M

LEGEND

- (hatched box) – Process options and technologies that have been screened out
- (open box) – Process options and technologies that are potentially applicable

A summary of the process options remaining after phase one screening is presented in Table 5-8.

5.5 Soils

5.5.1 Scope of Remediation

The landfill, including the Waste Pit, covers an area of approximately 50 acres at the site. As described in Section 1.3, municipal wastes were disposed in the landfill, industrial sludges and liquids were disposed of in a 5-acre depression (the Waste Pit), and mine spoil was used for daily cover throughout the 50-acre landfill. Portions of the landfill and the Waste Pit area have been capped using local clay and soil. The surficial soils of the area pose a potential future risk from dust inhalation, and the potential exists for contaminants to be leached from the landfill and Waste Pit to ground water. The remedial objectives for the landfill, Waste Pit, and surrounding area are to limit public exposure to surficial soils and to prevent future leaching of contaminants.

The Waste Pit consists of mine spoil, silt, garbage, oil, and clay. Samples collected from borings within the Waste Pit indicated that volatile organic compounds, semivolatile organic compounds, and metals were all present within the Waste Pit. However, the materials in the Waste Pit are not distributed in a homogeneous manner, and the contaminant concentrations vary significantly throughout the Waste Pit. In general, the permeability of the materials in the Waste Pit are low. The Waste Pit intercepts the Wegee limestone, and Waynesburg coal water-bearing zones. A majority of the material around the Waste Pit is mine spoil and fractured bedrock.

In general, the landfill outside the Waste Pit consists of a heterogeneous mixture of municipal garbage and mine spoil. Samples of the landfill soils indicated low concentrations of volatile organic compounds, low concentrations of semivolatile organic compounds typical of pre-landfill conditions, and heavy metals typical of pre-landfill conditions. The landfill soils are underlain by mine spoil, virgin soil, and fractured bedrock. The depth of the landfill soils is approximately 10 to 50 feet.

5.5.2 Phase One Screening

The remedial technologies and process options associated with general response actions for the Waste Pit and landfill soils were identified as shown on Table 5-9. Those technology types related to containment of ground-water flow (vertical barriers and horizontal barriers) were discussed and rejected in Section 5.2. Those technology types are not considered in this section.

TABLE 5-8. SUMMARY OF PROCESS OPTIONS REMAINING AFTER PHASE TWO SCREENING FOR SURFACE LEACHATE SEEPS (AND GROUND WATER)

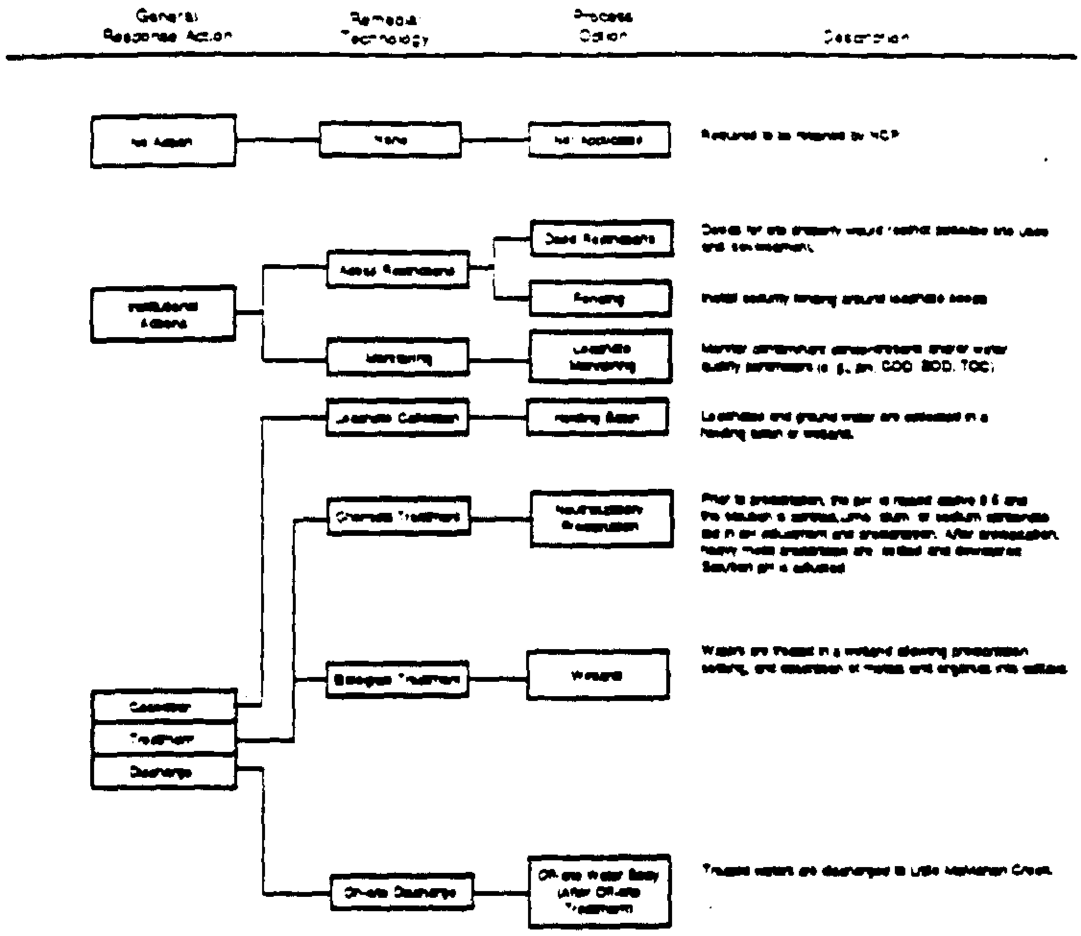
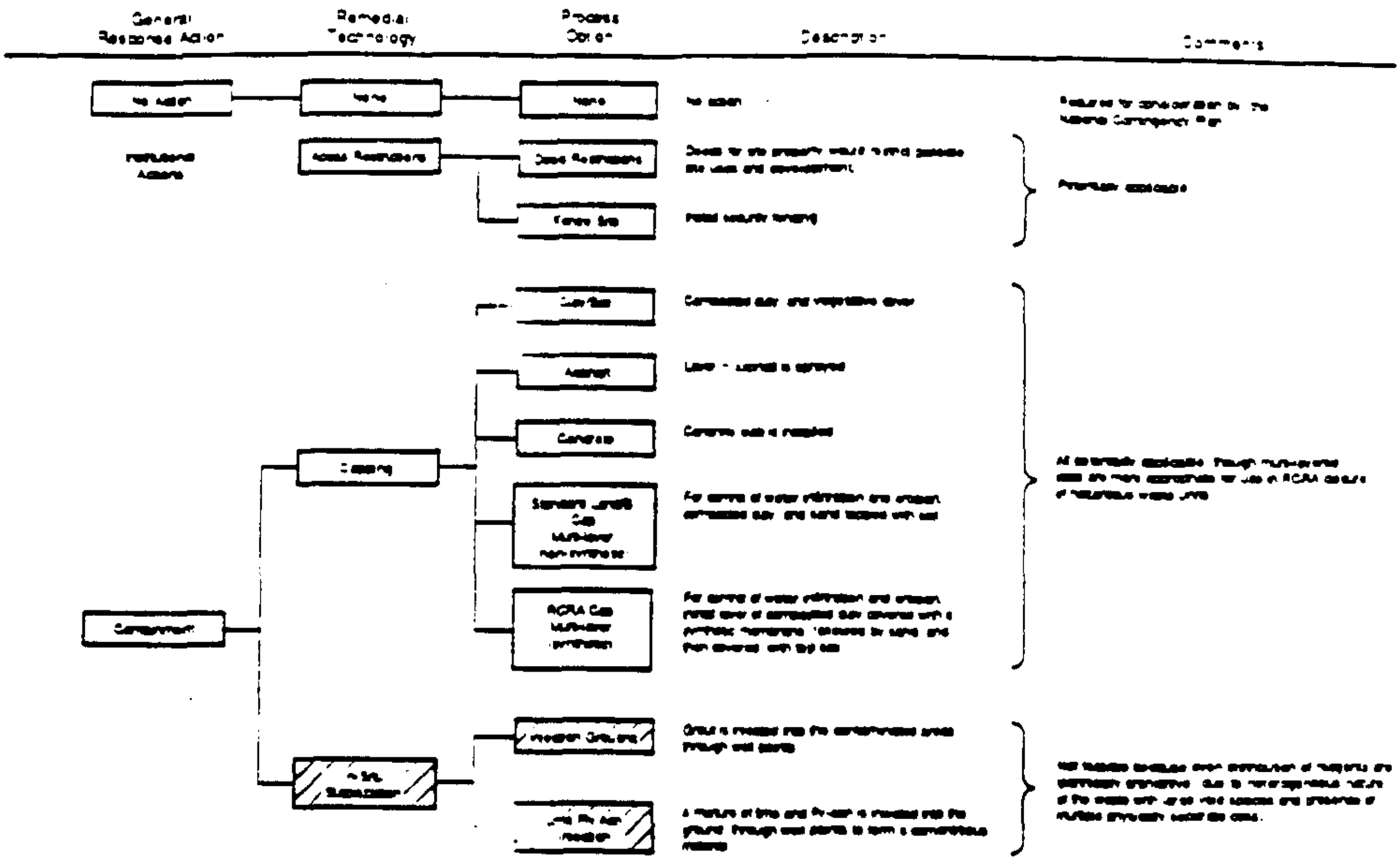


TABLE 5-9. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR WASTE PIT AND LANDFILL SOILS



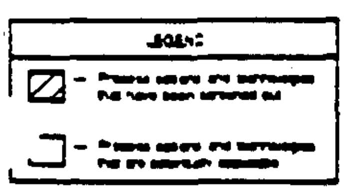


TABLE 5-9. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR WASTE PIT AND LANDFILL SOILS (Continued)

General Response Action	Remedial Technology	Process Option	Description	Comments
Soil Treatment	Biodegradation	Composting	[illegible]	[illegible]
		Solid Phase Treatment	[illegible]	
		In Situ Biodegradation	[illegible]	
		Slurry Phase Treatment	[illegible]	[illegible]
	Physical/Chemical Treatment	Chemical Oxidation/Reduction	[illegible]	[illegible]
		Removable Sorbents	[illegible]	[illegible]
		Soil Washing	[illegible]	[illegible]
		Dechlorination Process	[illegible]	[illegible]
		Thermal Volatilization	Vaporization of organic compounds in a soil drying unit.	[illegible]
		In Situ Vapor Extraction	[illegible]	[illegible]
		Soil Flushing	[illegible]	[illegible]
		In Situ Chemical Treatment	[illegible]	[illegible]
		Solidification/Stabilization	[illegible]	Potentially applicable

LEGEND

- Process options and technologies that have been screened out (shown hatched)
- Process options and technologies that are potentially applicable

TABLE 5-9. IDENTIFICATION AND PHASE ONE SCREENING OF PROCESS OPTIONS FOR WASTE PIT AND LANDFILL SOILS (Continued)

General Response Action	Remedial Technology	Process Option	Description	Comments
Soil Treatment (Continued)	Thermal Destruction	Pyrolytic Incineration	Destruction of soil contaminants in a chamber containing [illegible]. [illegible] and nonvolatiles are [illegible] off.	Potentially applicable when followed by a treatment technology that is applicable for high metal concentrations in soil.
		Rotary Kiln Incineration	Combustion of solids in a horizontally rotating cylinder designed for uniform heat transfer.	
		High Temperature Fluid Wall Reactor	Soil is fed into a high temperature, fluid-wall reactor, where rapid and thorough heating occurs.	
		Multiple Hearth Incineration	Soils are thermally destroyed as they slowly are moved through vertically stacked hearths.	
		Fluidized Bed Incineration	Soils are added to a hot, agitated bed of sand, where heat transfer and combustion occur.	
		Wet Air Oxidation	Oxidation of organics in a reactor under high temperature and pressure.	
		Molten Salt Incineration	Soils are fed into a furnace with molten salt bed acting as a [illegible] and a dispersing medium for destroying wastes by oxidation.	Not feasible because technology has not been proven on a large scale for the various wastes present in the Waste Pit and Landfill.
		Plasma Arc Incineration	Thermal destruction of contaminants using high-energy free electrons for molecular fracture.	
		Infrared Incineration	Soils are exposed to infrared radiation generated from infrared thermal units equipped with silicon carbide elements.	Potentially applicable when followed by a treatment technology that is applicable to high metal concentrations in soil.
		In Situ Vitrification	Soil is fused in-situ into a glassy, stable matrix by heating it in place with an electric current.	Not feasible because only demonstrated for hazardous waste treatment on bench-and pilot-scale tests; not yet tested on large scale or actual applications.
Removal, Transportation and Off-Site Treatment or Disposal	Treatment or Disposal of Excavated and Transported Waste	RCRA Facility	Transport untreated soils to a RCRA approved facility for treatment and/or disposal.	Potentially applicable

LEGEND

- Process options and technologies that have been screened out (hatched box)
- Process options and technologies that are potentially applicable (open box)

During phase one of the screening process, these technologies and options were screened with respect to their implementability at the BRL site. Many of the technologies and options initially identified were eliminated from further consideration because 1) site conditions, such as the fractured bedrock zones, low permeability of the bedrock zones, and heterogeneous nature of the mine spoil and landfilled materials, limited the feasibility of certain options; 2) specific options were not technically feasible for the type and range of contaminants in the soils; and 3) some options had not been proven on a large scale for the types and concentrations of wastes in the soils. Some of the remaining options were potentially applicable only when used in conjunction with other options. Details for each process option are presented on Table 5-9. Table 5-10 summarizes those remedial technologies and process options remaining after the phase one screening was completed.

5.5.3 Phase Two Screening

The remedial technologies and process options remaining after the phase one screening for Waste Pit and landfill soils were evaluated in greater detail in this second phase. These technologies and options were screened with respect to their effectiveness, implementability, and relative cost as shown on Table 5-11. Particular emphasis was placed on each option's effectiveness. During this screening process, options and technologies were compared to each other to evaluate their relative effectiveness, implementability, and cost.

Based on this evaluation, all the thermal destruction options were eliminated from further evaluation based on a comparison with other on-site soil treatment options for the reasons provided on Table 5-11. Table 5-12 summarizes those remedial technologies and process options remaining after phase two screening.

5.6 Summary of Screening Results for All Environmental Media

The general response actions, remedial technologies, and process options which passed Phase II screening are summarized in Table 5-13 with a brief description of each process option as it would be applied to the BRL site.

The "No Action" and "Institutional Action" apply to all environmental media and are carried through to detailed evaluation.

TABLE 5-10. SUMMARY OF PROCESS OPTIONS REMAINING AFTER PHASE ONE SCREENING FOR WASTE PIT AND LANDFILL SOILS

General Response Action	Remedial Technology	Process Option	Description
No Action	None	None	No action
Institutional Actions	Access Restrictions	Deed Restrictions	Deeds for the property would restrict possible site uses and development.
		Fence Site	Install security fencing
Containment	Capping	Clay	Compacted clay
		Asphalt	Layer of asphalt is applied
		Concrete	Concrete slab is installed
		Standard Landfill Cap Multi-Layer Non-synthetic	[illegible]
		RCRA Cap Multi-Layer Synthetic	[illegible]
Soil Treatment	Physical Chemical Treatment	Solidification Stabilization	[illegible]
	Thermal Destruction	Pyrolytic Incineration	[illegible]
		Rotary Kiln Incinerator	[illegible]
		High Temperature Fluid Wall Reactor	[illegible]
		Multiple Hearth Incinerator	[illegible]
		Fluidized Bed Incineration	[illegible]
		Wet Air Oxidation	[illegible]
		Infrared Incineration	[illegible]
Removal, Transportation, and Off-site Treatment or Disposal	Treatment or Disposal of Excavated and Transported Waste	RCRA Facility	[illegible]

TABLE 5-11. PHASE TWO SCREENING OF PROCESS OPTIONS FOR WASTE PIT AND LANDFILL SOILS

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
No Action	None	Not Applicable	Required to be considered by NCP. Does not achieve remedial action objectives	Not acceptable to local/public government	None
Institutional Actions	Access Restrictions	Deed Restrictions	Effectiveness depends on continued and future site use. Contaminants remain onsite; does not reduce contamination. Reduces direct contact risk by controlling land use	Easily implemented	Negligible cost
		Fence Site	Effectiveness depends on continued and future use. Contaminants remain onsite; does not reduce contamination. Reduces direct contact risk by restricting receptors	Easily implemented	Low capital cost. Very low O&M cost
Containment	Capping	Clay/Soil	Effective and self healing. Could be satisfactory supplement to RCRA or standard landfill in upslope areas. Will be combined with caps below as a design modification	Easily implemented. Restrictions on future land use required	Low capital cost, Low maintenance cost
		Asphalt	Effective but susceptible to weathering and cracking. Duplicative of other options	Easily implemented. Restrictions on future land use required	Low capital cost but high maintenance costs because of poor weathering, brittleness with age, photodecay, [illegible] and settlement cracking
		Concrete	Effective but susceptible to weathering and cracking. Duplicative of other options	Easily implemented. Restrictions on future land use required	Moderate capital cost. High maintenance cost
		Standard Landfill Cap Multi Layer (Non Synthetic)	Effective, less susceptible to cracking. Has self healing properties	Easily implemented. Restrictions on future land use required	Moderate capital cost. Low O&M cost
		RCRA Cap Multi Layer (Synthetics)	Effective, less susceptible to cracking. Has self healing properties	Easily implemented, though requires greatest time to implement. Restrictions on future land use required	High capital cost, low O&M cost
Soil Treatment	Physical/Chemical Treatment	Solidification/Stabilization	Effective for immobilizing metals and organics, provided total concentrations of semi volatile organics, polyaromatic hydrocarbons, and cyanides are within acceptable ranges so as not to interfere with binding of waste materials. Reliable, conventional technology. Requires treatability testing of affected soils	Difficult to implement due to large volumes of [illegible]	High capital cost, low O&M

LEGEND

- Hatched box – Process options and technologies that have been screened out
- Open box – Process options and technologies that are potentially applicable

TABLE 5-11. PHASE TWO SCREENING OF PROCESS OPTIO[illegible] [illegible]R WASTE PIT AND LANDFILL SOILS (CONTINUED)

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
	Thermal Destruction	Pyrolytic Incineration; Rotary Kiln Incineration; High Temperature Fluid Wall Reactor; [illegible]; Fluidized Bed Incineration; Wet Air Oxidation; Infrared Incineration	Effective only for most organic compounds. Further treatment and/or disposal would be required for the residual ash, which would contain elevated metal concentrations. Effectiveness of operation may be hindered by presence of inorganic components (e.g., metals).	Difficult to implement due to large volumes of materials onsite. Implementation requires excavation of material and poses great health [illegible]	High capital cost. High O&M cost. Costs would be further increased because of treatment and/or disposal required for residual ash.
Removal, Transportation and Off-site Treatment or Disposal	Treatment or Disposal of Excavated and Transported Wastes	RCRA Facility	Effective and reliable treatment. Transportation required. Does not reduce mobility, volume or toxicity.	Difficult to implement; nearest RCRA facility is 150 miles away.	High transportation and treatment/disposal costs.

LEGEND

- Process options and technologies that have been screened out (hatched box)
- Process options and technologies that are potentially applicable (open box)

TABLE 5-11. PHASE TWO SCREENING OF PROCESS OPTIO[illegible]R WASTE PIT AND LANDFILL SOILS (CONTINUED)

General Response Action	Remedial Technology	Process Option	Screening Criteria: Effectiveness	Screening Criteria: Implementability	Screening Criteria: Cost
	Thermal Destruction	Pyrolytic Incineration Rotary Kiln Incineration High Temperature Fluid Wall Reactor [illegible] Fluidized Bed Incineration Wet Air Oxidation Infrared Incineration	Effective only for most organic compounds. Further treatment and/or disposal would be required for the residual ash, which would contain elevated metal concentrations. Effectiveness of operation may be hindered by presence of inorganic compounds (e.g. arsenic).	Difficult to implement due to large volumes of materials onsite. Implementation requires [illegible]	High capital cost. High O&M cost. Costs would be further increased because of treatment and/or disposal required for residual ash.
Removal, Transportation and Off-site Treatment or Disposal	Treatment or Disposal of Excavated and Transported Wastes	RCRA Facility	Effective and reliable treatment. Transportation required. Does not reduce mobility, volume or toxicity.	Difficult to implement, nearest RCRA facility is 150 miles away.	High transportation and treatment/disposal costs.

LEGEND

(hatched box)	Process options and technologies that have been screened out
(open box)	Process options and technologies that are potentially applicable

TABLE 5-13

SUMMARY OF PROCESS OPTIONS FOR ALL ENVIRONMENTAL MEDIA REMAINING AFTER PHASE II SCREENING

Environmental Media	General Response Action	Remedial Technology	Process Option	Description
General Site	No Action	None	Not Applicable	No action taken. Required to be considered by the NCP
	Institutional Action	Access Restrictions	Deed Restrictions	Deeds for site property would restrict future uses of ground and surface waters and restrict the depth of excavation
			Fencing	Secure fence would restrict access by trespassers
		Monitoring	On-site Waters	Ground water and surface water monitoring required to evaluate the performance of remedial actions
			Off-site Residential Wells	Required to monitor residential wells periodically to ensure no contamination from the site
Soils	Containment	Capping	Standard Landfill Cap (multi layer, non synthetic)	A standard landfill cap is emplaced over the 50 acre landfill (including the Waste Pit) and surrounding soils to comply with Ohio Administrative Code requirements. Erosion controls implemented. Thinner cap may be installed in areas outside the landfill
			RCRA Cap (multi layer, synthetic)	A RCRA cap is emplaced over the 50 acre landfill and surrounding soils. The RCRA cap differs from the Standard Landfill Cap by use of a synthetic membrane liner and the need to have slopes less than 5% on average.

TABLE 5.11

SUMMARY OF PROCESS OPTIONS FOR ALL ENVIRONMENTAL MEDIA REMAINING AFTER PHASE II SCREENING

(Continued)

Environmental Media	General Response Action	Remedial Technology	Process Option	Description
Ground Water	Containment	Capping	As Above for Soils	The containment options for soils also accomplish a remedial objective for ground water of reducing or eliminating infiltration
	Collection	Subsurface Drains	Pipe and Media Interceptor Trench (French Drain) (Flow combined with surface leachate collection and treatment system)	Ground water is intercepted along Kings Run by a French Drain emplaced along reaches where Kings Run is a gaining stream (at a minimum) and conveyed to the surface leachate collection system for treatment and discharge. The need for a French Drain at the southern end of the landfill will be evaluated during design.
Surface Leachate Seeps	Collection	Surface Collection and Routing	Holding Basin or Wetland	Surface leachates will be collected by installing perforated pipe at seeps and routing by gravity flow to central collection point near the southern end of the landfill. Flows combined with ground water from the French Drain for common treatment and discharge
	Treatment	Chemical Treatment	Neutralization/Precipitation	Contaminated ground water and surface leachate flows would be treated by pH neutralization and precipitation in a holding pond or constructed holding basin
		Biological Treatment	Wetland	Contaminated ground water and surface leachate flows would be neutralized and treated in a constructed wetland
	Discharge	Off Site Discharge	To Little McMahon Creek	Discharge to Little McMahon Creek after treatment with monitoring as required for NPDES discharge permit

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TABLE 5.11

SUMMARY OF PROCESS OPTIONS FOR ALL ENVIRONMENTAL MEDIA REMAINING AFTER PHASE II SCREENING

(Continued)

...onmental Media	General Response Action	Remedial Technology	Process Option	Description
...face Water (...ngs Run)	Remediate Sources of Contamination	As above for soils, ground water, and surface leachate seeps.		The remedial action objective for Kings Run will be accomplished by remediating existing sources of contamination in 1) ground water discharges, 2) surface leachate seeps which cause contamination of baseflow and storm runoff, and 3) capping of surficial soils and implementation of erosion controls to prevent contamination during stormflow

Remedial technologies and process options for soils consider a treatment technology (solidification stabilization) applied to the Waste Pit below the surface, which may be distinguished as a separate potential source of contamination, and containment by capping of the entire landfill (including the Waste Pit) and the surrounding soils sufficient to prevent public exposure to the soils and to reduce infiltration, and to prevent contamination of surface water (Kings Run) by storm runoff. Two capping options will be considered representing extremes in technical requirements and cost; a full RCRA cap over the 50-acre landfill and surrounding soils and a standard landfill cap meeting Ohio Administrative Code (OAC) requirements for regular landfill closure over the 50-acre landfill and surrounding soils. The extent of the cap over the surrounding soils will be determined from the standpoint of 1) that required to prevent recharge to on-site ground water, or 2) that required to restrict public exposure to surficial soils, whichever is more extensive.

The thickness of cap required on the 50-acre landfill is fixed at a minimum by the State ARAR (OAC requirements for landfill closure) at 2 feet of compacted clay, 1-foot of sand for drainage, and 2 feet of top soil to support vegetative cover. The thickness of cap in areas outside the landfill is constrained by the remedial objectives to significantly reduce or eliminate recharge to ground-water bearing zones and restrict public exposure. The thickness of cap required in areas outside the 50-acre landfill will be evaluated during design.

Protection of the Kings Run watershed will be achieved through an integrated network of french drains and collection at surficial discharge points (leachate seeps). Remedial technologies and process options for ground-water remediation include containment by capping which is accomplished by the containment options for soil remediation, and collection by subsurface drain (French Drain) installed along Kings Run at least at those portions where the Remedial Investigation showed Kings Run to be a gaining stream. Collected ground water would be routed by gravity and combined with flows collected in the surface leachate collection system for common treatment. Ground water near the southern end of the landfill appears to emerge as a major surface leachate seep and will be collected at the point of emergence (Leachate L-4). The Agencies' primary objective is to prevent discharge of contaminated waters, either ground water or leachates, from the landfill. The Agencies believe that a french drain would be the most effective and reliable means of intercepting liquids emanating from the landfill. This specifics of the leachate collection system will be resolved during remedial design. During pre-design, ground-water levels along Kings Run will be monitored seasonally to fully characterize flow conditions, and the design of the French drain system will be modified as needed.

Surface leachate seeps which currently drain toward Kings Run will be collected by installing perforated pipe at each such seep studied during the Remedial Investigation (specifically, Leachates L-1, L-2, L-4, and L-5). Flows will be routed by gravity and combined with flows from the French Drain system for common treatment near the southern end of the landfill and discharge of treated water by gravity to Little McMahon Creek. Other site-derived leachate seeps that may be discovered during RD RA activities will also be remediated.

Options for treatment of the combined ground water and surface leachate flows include chemical treatment by neutralization and precipitation, and treatment in an on-site wetland. Both options will be carried through tc detailed evaluation.

The remedial objectives for surface water in Kings Run will be accomplished by implementation of remedial action in the sources of surface water contamination. No separate remediation of Kings Run will be required.

6.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

6.1 Introduction

In assembling remedial alternatives, Versar combined general response actions and the process options chosen to represent the various technology types for each medium (or operable unit) to form viable, potentially effective site-wide remedial plans. Alternatives are developed and assembled to be consistent with the set of remedial action objectives specified for media at the BRL site. Also, the alternatives address the known interactions between site media (e.g., soil, ground water, leachate) in identifying contaminant sources or effects possibly requiring remediation.

Each remedial alternative assembled for the BRL site includes site institutional actions. These measures may include implementing deed restrictions on site property, or installing fences to restrict access to specific affected areas of the site or both. Access restrictions serve to limit or prevent direct contact with possibly hazardous or toxic material.

For each designated Alternative 1 through 4, various process options are combined into comprehensive, site-wide remedial plans. Process options that survived screening are presented in the following categories:

- Soil Remediation. This process option pertains to the Waste Pit and landfill surficial soil and surrounding areas as required by the ARARs (standard landfill cap or RCRA cap).

- Ground-Water Remediation. This process option pertains to the containment and collection (underdrain and French drains) as well as treatment (physical/chemical approach or biological method) and off-site discharge.

- Surface Leachate Seep Remediation. This process option pertains to the containment and collection (French drains) as well as treatment (physical/chemical approach or biological method) and off-site discharge.

The various process options that comprise the site-wide remedial alternatives are discussed in greater detail below.

6.1.1 Description of Institutional Actions

The institutional actions selected in developing the remedial alternative for the BRL site include fencing, deed restrictions, ground-water monitoring, surface leachate seep monitoring, and monitoring of Kings Run.

Fencing prevents unauthorized access to the site and deed restrictions limit ownership to the site. Consideration of these two options is intended to limit or eliminate the number of people who may get in contact with and potentially exposed to hazardous wastes at the site.

Ground-water monitoring consists of the monitoring of on-site wells and domestic wells as specified within each remedial alternative. The number of wells to be monitored and the duration of monitoring activities varies depending upon the other options proposed for the remedial alternative. Specific sampling frequencies will be determined during RD/RA activities. Sampling frequencies cited in the FS Report are for cost estimating purposes only. For the remedial options that include capping of recharge areas surrounding the Waste Pit, it is estimated that 9 on-site wells would be monitored semiannually for 5 years, and 12 on-site wells and 2 domestic wells would be monitored semiannually for 30 years. This estimate is based on the assumption that within 5 years of the cap installation, 9 of the on-site wells would no longer yield water. For costing the other remedial alternative, it was estimated that 23 on-site wells and 2 domestic wells would be monitored semiannually for a 30-year period. Both the number of wells, and sampling periods will be determined during remedial design (RD).

Four leachates (L-1, L-2, L-4, and L-5) would be sampled three times per year, twice under dry conditions and once under wet conditions. In alternatives involving capping recharge areas surrounding the Waste Pit, L-1 and L-2 are assumed (for costing purposes only) to be dry in 5 years or less. Samples will be analyzed for volatile and semivolatile organic compounds and heavy metals. Other site-derived leachates that may be discovered during RD/RA activities will also be sampled.

Costing for the surface water monitoring option considers that the surface water in Kings Run would be monitored at 3 stations (including a background station) 3 times a year for a 30-year time period. Monitoring results would provide information about site conditions and, when applicable, an indication of the effectiveness of remedial options for other media at the site.

6.1.2 Description of Options for Landfill Soils

Two process options remain for the general response action of containment of the Waste Pit and landfill soils. One option is to construct a cap meeting the RCRA cap design; the other is to construct a cap meeting the OAC standard landfill cap design requirements. Both designs would also include capping of ground water recharge areas to the Waste Pit from its surrounding soils. The two capping options are slightly different in design. The RCRA Cap (Figure 6-1) covers a larger area than the standard landfill cap (Figure 6-2). The increased areal coverage of the RCRA cap would also require modification in the types of drainage channels that would be required by the standard landfill cap. It should be noted that grading requirements for both the RCRA and standard landfill cap will be difficult, or impractical to achieve for limited areas of the landfill due to the great topographic relief present on the BRL site.. The grading requirements presented in the following paragraphs will serve as guidance criteria during the remedial design process. These two process options are described below.

6.1.2.1 RCRA Cap

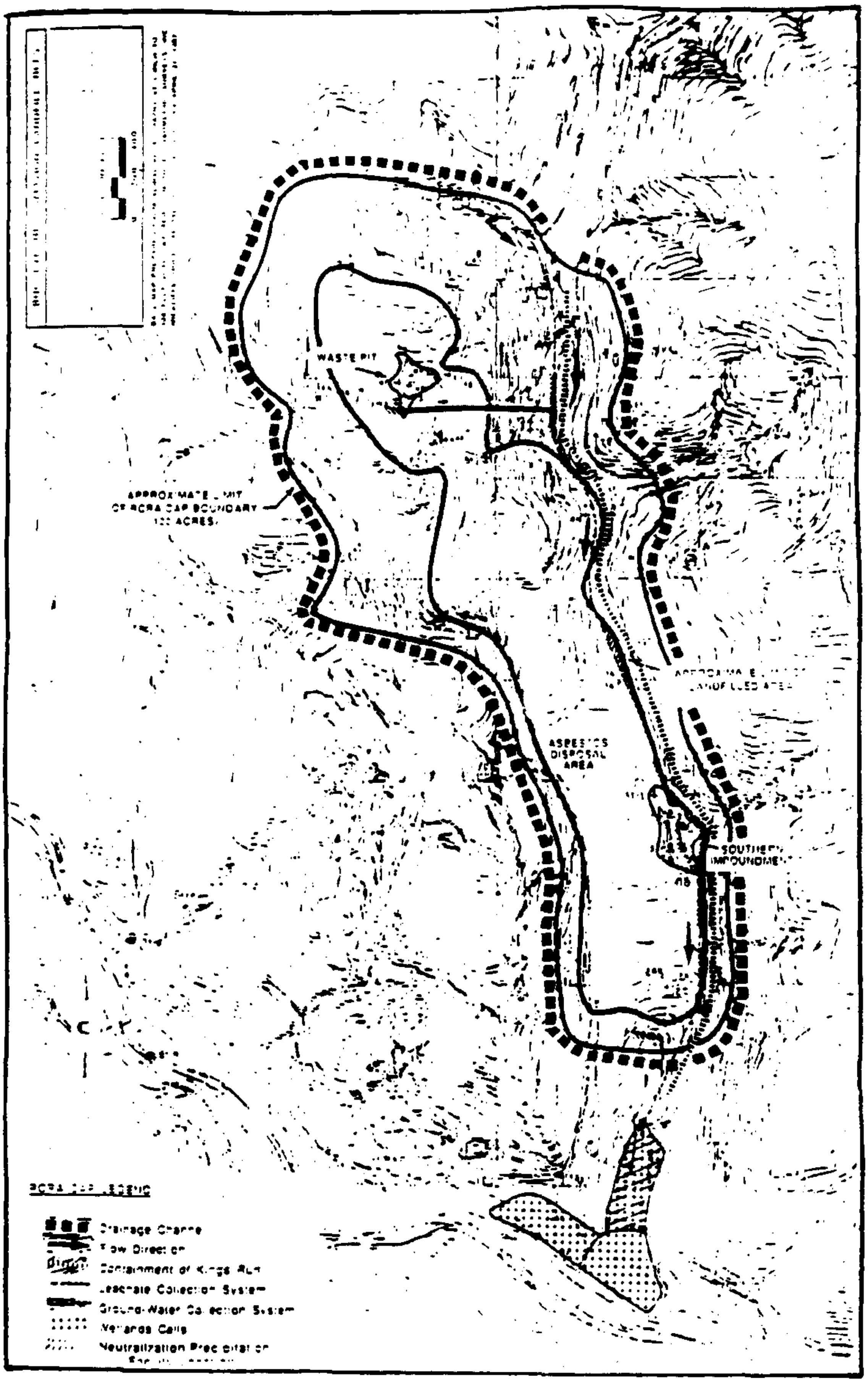
This option involves leaving the Waste Pit material in place and covering the solid waste landfill area, the Waste Pit, and suspected sources of recharge for the Waste Pit and water-bearing zones potentially in contact with it with a full RCRA cap. The purpose of the cap would be to eliminate infiltration of precipitation through the landfilled material, minimize human and animal contact with the landfilled material, control surface flushing of acid-producing material to surface waters, and reduce the spread of acid-producing material by air and water erosion. The cap would be expected to minimize contamination of surface water runoff and the dispersion of hazardous wastes and contaminated surface soil by wind.

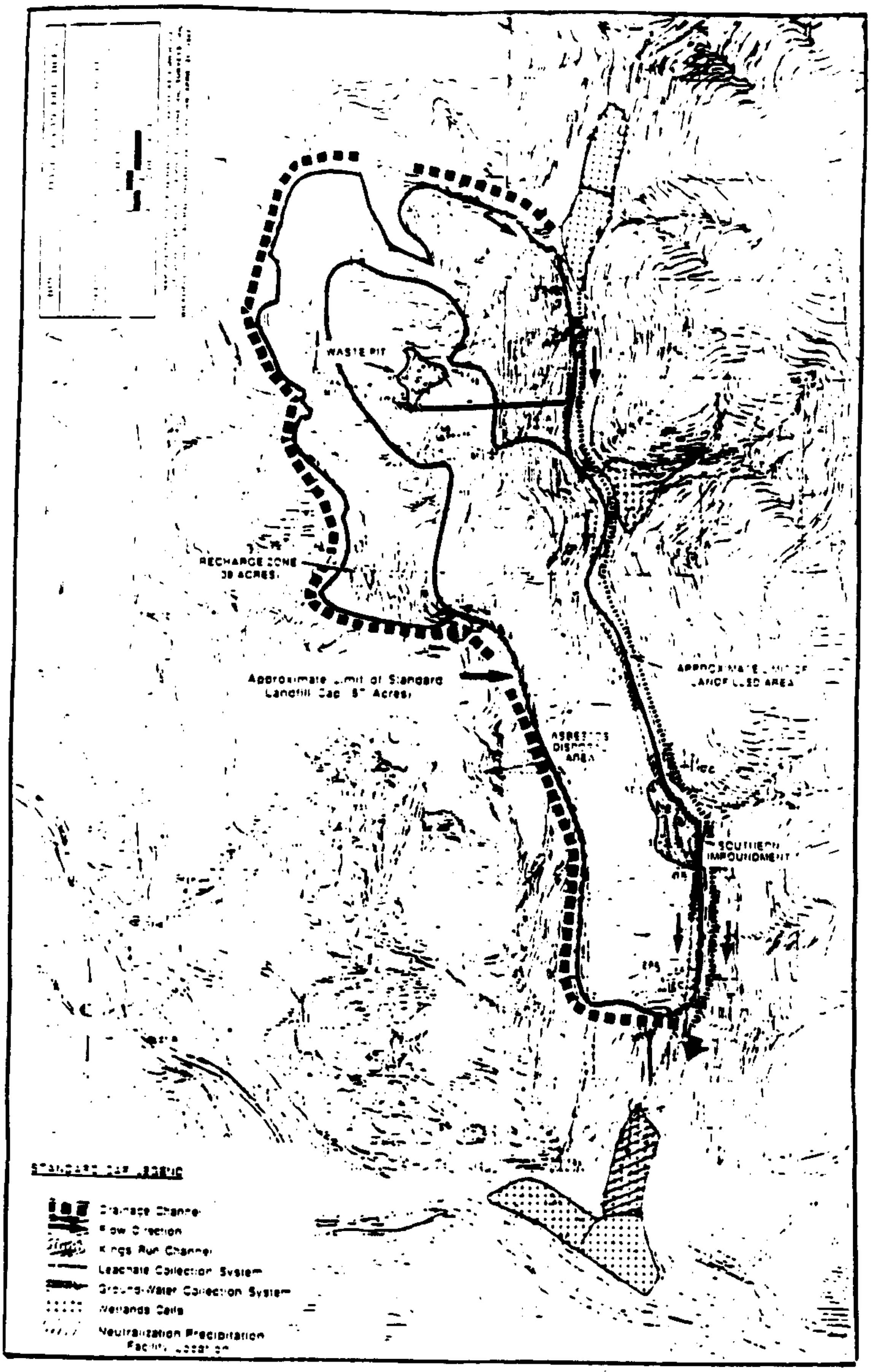
The installation of a full RCRA cap would involve grading and excavation of soil and rippable rock, adding borrow material to excavated materials from other areas of the site to prepare the surface bed for cap installation, capturing Kings Run in a subsurface pipe, installing the cap materials, and placing a surface drainage system to divert surface water runoff around the cap. A French drain and surficial leachate collection system to protect the Kings Run watershed would also be required to compliment the cap (Figure 6-1).

Cap Design

A multi-layered RCRA cap consists of a vegetated top cover, a middle drainage layer, and a low permeability layer. This design for a RCRA cap is recommended by the EPA. The cap functions by diverting infiltrating liquids from the vegetated layer through the drainage layer away from the capped material and by promoting surface water runoff. The cap will extend to the unaffected slopes at a 5% gradient to the east, thus covering Kings Run, and extend to the unaffected slopes to the west and north.

The U.S. EPA recommends that the vegetated top layer of the multi-layer cap have a minimum thickness of 2 feet and consist of topsoil that can support vegetation. Freezing and thawing cycles can greatly increase the permeability of a soil, thereby, reducing the effectiveness of the cap. Whereas the frost line in southeastern Ohio is at a depth of approximately 18 inches, a thickness of 2 feet will prevent frost from penetrating the low permeability layer of the cap. A well-mixed cover of grasses and legumes such as Kentucky bluegrass, clover, and red top and fescue will provide a dense root system to anchor the soil and minimize wind and water erosion. Vegetation will be established by


WASTE PIT
APPROXIMATE LIMIT OF RCRA CAP BOUNDARY
ASBESTOS DISPOSAL AREA
SOUTHERN IMPOUNDMENT
RCRA CAP LEGEND
Drainage Channel
Flow Direction
Containment of Kings Run
Leachate Collection System
Ground-Water Collection System
Wetlands Cells
Neutralization Precipitation


WASTE PIT
RECHARGE ZONE
39 ACRES
Approximate Limit of Standard
Landfill Cap (57 Acres)
ASBESTOS
DISPOSAL
AREA
APPROXIMATE LIMIT OF
LANDFILLED AREA
SOUTHERN
IMPOUNDMENT
STANDARD CAP LEGEND
Drainage Channel
Flow Direction
Kings Run Channel
Leachate Collection System
Ground-Water Collection System
Wetlands Cells
Neutralization Precipitation
Facility Location

hydromulching the surface of the cap. The final top slope, after allowances for settling and subsidence, will be between three and 5 percent.

The drainage layer is located directly below the vegetated top layer and has a minimum thickness of 1 foot. The saturated hydraulic conductivity of this layer should not be less than 1 x 10^{-3} cm/sec. A clean sand would be a suitable material for this layer. Infiltration is intercepted and channeled to the surface water drainage system by this layer.

A geomembrane would to be placed beneath the 1-foot layer of sand. The geomembrane is essentially impermeable and should allow virtually no infiltration to the materials below it. The geomembrane should have a minimum thickness of 20 mils and be made of high density polyethylene (HDPE). Six-inch layers of bedding material no coarser than Unified Soil Classification System (USCS) sand (SP), which is free of rock, fractured stone, debris, cobbles, rubbish, and roots, located above and below the geomembrane, are intended to protect the geomembrane from tears and punctures.

A low permeable soil layer with a minimum thickness of 2 feet as recommended by the EPA would then be placed below the geomembrane sand unit. The low permeability soil layer is designed to provide assurance of continued protection should the geomembrane fail. The permeability of the recompacted clay or other natural materials used in the low permeability soil layer must have a maximum value of 1 x 10^{-7} cm/sec as required by 40 CFR 264, Subpart N. If suitable material for this layer is not available on site, clay or other material may need to be imported from the local area to attain the required permeability. The 2-foot thick, low permeability soil layer will be compacted in six-inch lifts to maximize the effectiveness of compaction. The moisture content, placement and spreading of the low permeability soil layer material would be monitored to insure optimum compaction of the cap material. Quality Assurance/Quality Control (QA/QC) testing consists of moisture-density testing of the individual lifts as they are placed, and laboratory testing of the low permeability soil layer material permeabilities from Shelby tubes taken in the field. QA/QC testing would also be performed on borrow pit materials used in the construction of the low permeability soil layer.

The underlying base for the RCRA cap would consist of fill composed of excavated mine spoil and garbage from on site and borrow material from the local area. This base will be capable of supporting the weight of the cap without damaging the geomembrane. The upper 1-foot of the base would be compacted in two 6-inch lifts during placement.

Design Criteria for Containing Kings Run

For the RCRA cap option, Kings Run would have to be contained in two 36-inch diameter HDPE pipes located in the existing creek channel. These pipes would be required to accommodate the 100-year, 24-hour storm event. A precast concrete inlet would regulate flow from the Northern Impoundment to the pipes. Kings Run would discharge through a precast concrete outlet at the southern toe of the cap. A riprap apron with a median stone size of 12 inches should protect the outlet from erosion and act as an energy dissipator by reducing the flow velocity to the existing channel. Bedding preparation and grading has to be done before installation of the pipes in the existing Kings Run channel. Preparation is necessary to remove rocks, stones, debris, rubbish, and minimize any sudden slope changes.

Berms

North-south oriented berms would be constructed on the surface of the cap. The berms are designed to control the surface water runoff on the cap, therefore minimizing erosion.

The trapezoidal berms would be 1.5 feet high, 2 feet across the top, with 2:1 side slopes. The berms typically consist of compacted topsoil material and are grass-covered. The berms are designed to handle surface water runoff for a 100-year, 24-hour storm event.

Fourteen grass-lined open channels oriented east-west would transport water diverted by the berms down the cap slope to the drainage channels discussed in the following paragraph. The open channels would be located approximately every 300 feet along the cap. Channels should be trapezoidal with 2.5:1 side slopes, a base width and depth of 1 foot, and be lined with an erosion mat to minimize deterioration of the channel and to help maintain vegetation.

Drainage Channels

Drainage channels would be installed to the north, east, and west of the cap to collect surface water runoff from the cap and to divert the surface water runoff from the surrounding areas away from the cap and to protect it from erosion. The drainage channels would be designed handle only storm runoff and are designed for a 100-year, 24-hour storm event. Since the drainage channels are designed for no base flow, hydromulching would be used to establish vegetation in the drainage channels.

The northern drainage channel should be trapezoidal with 2:1 side slopes, a 1-foot wide base, and a depth of 1.25 feet. This northern channel would be fully lined with a grass such as Kentucky fescue or bluegrass having a retardance factor of B, as defined by the U.S.D.A. Soil Conservation Service. This channel should be designed to handle a peak flow of 11 cfs and discharge into the Northern Impoundment.

The western drainage channel would also be fully lined with grass having a retardance factor of B. however, it discharges into Kings Run at its east end. The channel should be trapezoidal with 2.5:1 side slopes, a 4-foot base, and a depth of 3 feet. This channel is designed to convey a peak flow of 85 cfs.

The eastern drainage channel should also trapezoidal, but lined with geotextile filter fabric and a 2-foot thick layer graded (d_{50} = 10 inches) riprap. The channel has 2.5:1 side slopes, a base width of 3 feet, and a depth of 2 feet. This channel is designed to handle peak flow of 160 cfs and discharge into Kings Run.

Grass-lined waterways would be used due to their simple design, easy installation, and low cost. The lower design flows of the northern and western drainage channels justify the use of grass-lined channels over riprap for these reasons. The grass-lined waterways will provide sufficient erosion protection without exceeding the maximum permissible velocity of 4 to 5 fps for the grasses while conveying the storm flow. The eastern channel would be riprapped to protect the channel from erosion during the design storm flow.

The installation of a grass-lined waterway in this instance would be impractical due to the width needed to reduce the storm flow to the maximum permissible velocity.

Quality Assurance/Quality Control (QA/QC)

A test cap, 50 feet by 100 feet, should be constructed to aid in the final cap design and to identify any material and construction problems prior to final cap construction. Moisture content, placement, and spreading of the low permeability soil layer material should be QA/QC monitored by the contractor to insure compaction requirements are met. QA/QC testing would consist of fill and borrow material classification, moisture-density testing during the placement of the 6-inch lifts, field permeability testing with an infiltrometer, and laboratory testing of permeability from Shelby tubes taken during the test cap construction. QA/QC testing would also be performed on borrow pit materials and the geomembrane used in the cap construction.

Post Closure Performance

Post closure care should continue for a period of 30 years after the closure date as required by 40 CFR 264, Subpart G. This period may be shortened or extended depending on the period required for sufficient protection of human health and the environment. Post closure care involves monitoring, regular inspections of the cap for erosion, subsidence, and/or settlement, and periodic maintenance such as repair of any erosion damage to the cap or any of the drainage channels from surface-water runoff.

Capping is a reliable technology for sealing off contamination from the surface environment and minimizing infiltration of precipitation. With infiltration minimized, leachate generation would be reduced. The performance of a multi-layered cap would generally be expected to be excellent for the first 20 years of operation; after this time period the cap should be inspected regularly. Inspections should be done at 5-year intervals. The cap is expected to have a life of between 50 and 100 years according to the manufacturer's specifications. The HDPE pipe that would be installed under the RCRA cap has a projected life of 30 years, according to the manufacturer's specifications.

6.1.2.2 Standard Landfill Cap

This option is similar to the RCRA cap design except the final cap slopes range from 5 to 25 percent, and the cap design would not incorporate an impermeable HDPE geomembrane. The solid waste landfilled area, the Waste Pit, and suspected sources of recharge for the Waste Pit and water-bearing zones potentially in contact with it will be covered with a solid waste landfill cap (Figure 6-2). The purpose of the cap would be to minimize infiltration of precipitation through the landfilled material, control surface flushing of acid-producing material to surface waters, and reduce the spread of acid-producing material by air and water erosion. The cap would also minimize contamination of surface water runoff and the dispersion of hazardous wastes and contaminated surface soil by wind. This alternative requires minimal cut and fill volumes and fewer cap materials.

The installation of a solid waste landfill cap would involve grading and excavation of the perimeter embankments consisting of soil and rippable rock, adding borrow material to excavated materials from other areas of the site to prepare the surface bed for cap installation, establishing erosion control measures, installing the cap materials, and placing a surface drainage system to divert surface water runoff around the north, west, and south sides of the cap. A french drain and surficial leachate collection system are also required to compliment the cap (Figure 6-2).

Landfill Cap Design

A solid waste landfill cap consists of a vegetated top cover, a middle drainage layer, and a low permeability layer. This design for a solid waste landfill cap is regulated by the Ohio Administrative Code (OAC) 3745-27-11. This cap differs from a RCRA cap in that no geomembrane or accompanying upper and lower cushions are present. The cap functions by diverting infiltrating liquids from the vegetated layer through the drainage layer away from the capped material and by promoting surface-water runoff.

The vegetated top layer of the multi-layer cap should have a minimum thickness of two feet and consist of topsoil that can support vegetation. Freezing and thawing cycles can greatly increase the permeability of a soil, thereby, reducing the effectiveness of the cap. Whereas the frost line in southeastern Ohio is at a depth of approximately 18 inches, a topsoil thickness of 2 feet would prevent frost from penetrating the low permeability layer of the cap. A well-mixed cover of grasses and legumes such as Kentucky bluegrass, clover, and red top and fescue will provide a dense root system to anchor the soil and minimize wind and water erosion. Vegetation would be established by hydromulching the surface of the cap. The final top slope, after allowances for settling and subsidence, should not exceed 25 percent as regulated by OAC 3745-27-11. The slopes should have a final grade of between 5 percent and 25 percent.

The drainage layer is located directly below the vegetated top layer and has a minimum thickness of 1 foot, as regulated by the OAC 3745-27-11. The saturated hydraulic conductivity of this layer should not be less than 1 by 10^{3} cm/sec. A clean sand would be a suitable material for this layer. Infiltration would be intercepted and channeled to the surface water drainage system by this layer.

The low permeability layer should consist of a low permeability soil with a minimum thickness of two feet as regulated by OAC 3745-27-11. The low permeability soil layer minimizes the amount of infiltration to the capped material. The permeability of the recompacted clay or other natural materials used in the low permeability soil layer should have a maximum value of 1 by [illegible] cm/sec. If suitable material for this layer is not available on site, clay or other material would need to be imported from the local area to attain the required permeability.

The 2-foot thick, low permeability soil layer should be compacted in six-inch lifts to maximize the effectiveness of compaction. The moisture content, placement and spreading of the low permeability soil layer material would be QA/QC monitored to insure optimum compaction of the cap material. Quality Assurance/Quality Control (QA/QC) testing would consist of moisture-density testing of the individual lifts as they are placed, and laboratory testing of the low permeability soil layer material permeabilities from Shelby tubes taken in the field. QA/QC testing will also be performed on borrow pit materials used in the construction of the low permeability soil layer.

The underlying base for the cap should consist of fill composed of excavated mine spoil and garbage from on site and borrow material from the local area. This base should be capable of supporting the weight of the cap. The upper 1-foot of the base would be compacted in two 6-inch lifts during placement.

Design Criteria for Minimizing Erosion of Kings Run

For the standard landfill cap option, erosion control measures would also need to be taken. Erosion of the west bank of Kings Run has been observed. To protect this bank from further damage and to preserve the integrity of the cap, the west bank would be lined with riprap. Kings Run would be riprapped from the Northern Impoundment and extend beyond the southern toe of the cap. Kings Run would then act as the eastern drainage channel for surface water runoff from the cap for this alternative.

The flow of Kings Run would be maintained in its current channel, however, minor bed shaping may be necessary. The channel would be lined with an 18-inch blanket of graded riprap (d_{50} = 20 inches) that extends approximately 7 feet up the west bank of Kings Run, 2.5 feet along the stream bottom, and has a 2.5-foot toe-in. A non-woven geotextile would be installed between the soil and the riprap to minimize soil movement into or through the riprap. The riprap along the channel bottom and in the toe-in should minimize undercutting of the riprap lining.

Berms

North-south oriented berms would be constructed on the cap. The berms would be designed to control the surface water runoff on the cap, therefore minimizing erosion.

The trapezoidal berms would be 1.5 feet high, 2 feet across the top, with 2:1 side slopes. The berms consist of topsoil material and are grass-covered. The berms have been designed to handle surface-water runoff for a 100-year, 24-hour storm event.

Grass-lined open channels oriented east-west would transport water diverted by the berms down the cap slope to Kings Run on the east, and the drainage channels discussed in the following paragraph on the north and south. Fourteen channels would be located approximately every 300 feet along the cap. Channels will be trapezoidal with 2.5:1 side slopes, a base width and depth of 1 foot, and should be lined with an erosion mat to minimize deterioration of the channel and to help maintain vegetation.

Drainage Channels

Drainage channels would be installed to the north and west of the cap to collect surface-water runoff from the cap and to divert the surface-water runoff from the surrounding areas away from the cap and to protect it from erosion. The drainage channels would handle storm runoff and are designed for a 100-year, 24-hour storm event. Since the drainage channels are designed for no base flow, hydromulching should be used to establish vegetation in the drainage channels.

The northern drainage channel should be trapezoidal with 2:1 side slopes, a 1-foot wide base, and a depth of 1.25 feet. This northern channel would be fully lined with a grass such as Kentucky fescue or bluegrass having a retardance factor of B, as defined by the U.S.D.A. Soil Conservation Service. This channel has been designed to handle a peak flow of 11 cfs discharge into the Northern Impoundment.

The western drainage channel would also be fully lined with grass having a retardance factor of B, however, it would discharge into Kings Run at its east end. The channel should be trapezoidal with 2.5:1 side slopes, a 4-foot base, and a depth of 3 feet. This channel has been designed to convey a peak flow of 85 cfs.

Grass-lined waterways would be used due to their simple design, easy installation, and low cost. The lower design flows of the northern and western drainage channels justify the use of grass-lined channels over riprap for these reasons. The grass-lined waterways would provide sufficient erosion protection without exceeding the maximum permissible velocity of 4 to 5 fps for the grasses while conveying the storm flow.

Quality Assurance/Quality Control (QA/QC)

A test cap, 50 feet by 100 feet, should be constructed to aid in the final cap design and to identify any material and construction problems prior to final cap construction. Moisture content, placement, and spreading of the low permeability soil layer material should be QA/QC monitored to insure compaction requirements are met. QA/QC testing would consist of fill and borrow material classification, moisture-density testing during the placement of the 6-inch lifts, field permeability testing with an infiltrometer, and laboratory testing of permeability from Shelby tubes taken during the test cap construction. QA/QC testing should also be performed o[illegible] borrow pit materials and the geomembrane used in the cap construction.

Post Closure Performance

Post closure care would continue for a period of 30 years after the closure date as required by OAC 3745-27-11. This period may be shortened or extended depending on the period required for sufficie[illegible] [illegible]otection of human health and the environment. Post closure care involves monit[illegible] [illegible]egula[illegible] [illegible]spections of the cap for erosion, subsidence and/or settlement, and peri[illegible] [illegible]ntena[illegible]ce such as repair of any erosion damage to [illegible]e cap or any of the drainage ch[illegible]s from surface water runoff.

Capping is a reliable technology for sealing off contamination from the surface environment and minimizing infiltration of precipitation. With infiltration minimized, leachate generation would be reduced. The performance of a solid waste landfill cap would generally expected to be excellent for the first 20 years of operation; after this time period the cap should be inspected regularly for integrity. The inspections would be done at 5-year intervals. The cap is expected to have a life of between 50 and 100 years, according to manufacturer's specifications.

6.1.3 Descriptions of Options for Ground Water

6.1.3.1 Ground-Water Collection

An underdrain collection system would be installed to intercept the ground water flowing from the landfill to Kings Run and the Northern Impoundment (which feeds into Kings Run). This system will be installed along the northeastern and eastern boundaries of the landfill, and connected to the underdrain collection system (near monitoring wells MW-8A, MW-9A, and MW-11A). This system would be installed below the existing grade and discharged to a treatment system located south of the site. The specifics of the system requirement will be determined during the remedial design phase.

For the purpose of developing remedial cost estimates, the underdrain will be considered a 3-foot wide by 5-foot deep rectangular channel with slopes between 4 to 9 percent. A 10-inch HDPE with perforation along the top half of the pipe would be placed inside this channel. This pipe would be placed on a 6-inch bedding of sand, covered with 1 foot of 3/8-inch (ODOT No. 8) coarse aggregate, and backfilled with topsoil. The pipe island, and aggregate would be enveloped with a geotextile filter fabric to minimize silting in the pipes.

For the three zones of Kings Run where a gaining stream is occurring, a French drain system would be installed. This system would work in conjunction with the surficial leachate collection system (see Section 6.1.4.1). The French drain would omit the topsoil backfill; instead, the channel would be completely backfilled with the 3/8-inch coarse aggregate and covered with the geotextile filter fabric. The length of the French drain would match the length of the gaining stream: approximately 595 feet near MW-8A, 525 feet near MW-9A, and 825 feet near MW-11A. The design of the French drain and underdrain collection system (i.e., depth, width, length, and location) will depend on specific information on ground-water flow conditions gathered during RD activities.

The perforated pipe in this collection system accommodates a flow of 495 gallons per minute (gpm)(or 1.10 cubic feet per second). This flow is the sum of the recharge to Kings Run from the ground water in the three areas where the French drain would be installed and leachate flows from L-1, L-2, L4, and L5.

6.1.3.2 Ground-Water Treatment

Two options are considered for the treatment of ground water collected using the system described above. The treatment involves a physical/chemical approach (neutralization/precipitation) or a biological method (wetlands) to remove metals (e.g., iron, aluminum, manganese, zinc, antimony, arsenic, and beryllium) from the ground water. These options will be affixed to certain remedial alternatives, essentially creating subalternatives. These treatment options are the same as those for the leachates to be discussed in detail in Section 6.1.4.2. The treated water would be discharged to Little McMahon Creek.

6.1.3.3 Ground-Water Monitoring

In addition to ground-water monitoring at selected wells (see Section 6.1.1), ground water and surface leachate seeps collected by the underdrain system would be sampled three times per year, twice under dry conditions, and once under wet conditions. For costing purposes, samples are assumed to be collected at the discharge and treatment and analyzed for volatile and semivolatile organic compounds and heavy metals. Specific sampling frequencies will be determined during RD/RA activities. Sampling frequencies cited in this FS Report are for cost estimating purposes only. The effluent from treatment would be sampled three times per year and analyzed for the same parameters as the untreated ground-water stream. Analytical parameters for ground-water monitoring will be determined during RD activities and specified in the NPDES permit.

6.1.4 Descriptions of the Options for Surface Leachate Seeps

6.1.4.1 Collection of Surface Leachate Seeps

A French drain system would also be installed to collect the surface leachate seeps (L-1, L-2, L-4, and L-5). This system will be connected to the underdrain collection system (see Section 6.1.3.1). The leachate will be combined with the collected ground water and discharged to a treatment system located south of the site. The leachate seeps at L-2 and L-4 would be collected locally with a French drain and piped to the underdrain piping; the seeps at L-1 and L-5 would be collected locally with a French drain directly above the underdrain piping and should not require any additional piping.

The French drain design would be similar in design to those used for the collection of ground water at the three locations of gaining stream, only their size would be limited to be 3 feet square by 5 feet deep. The pipes to be used to transport the leachates L-2 and L-4 to the underlain system are HDPE pipes installed on a 6-inch bed of sand and backfilled with borrow material. The pipes should be placed on slopes of 4 to 9 percent with the exception of the pipe for L-2 where a slope near 29 percent will be required on the eastern side of the landfill. Expected flow rates for various surface leachate seeps are as follows: L-1: 1.5 gpm, L-2: 1.5 gpm, L-4: 100 gpm, L-5: 20 gpm. Description of the underdrain collection system is provided in Section 6.1.3.1.

6.1.4.2 Treatment of Surface Leachate Seeps

Two options are considered for the treatment of surface leachate seeps collected. the system described above and in Section 6.1.4.1. The treatment involves a physical chemical approach (neutralization/precipitation) or a biological method (wetlands) to remove metals (e.g., iron, aluminum, manganese, zinc, and antimony) and contaminants of concern from the surface leachate seeps. These alternatives will be affixed to certain remedial alternatives, essentially creating subalternatives. Descriptions of these two treatment options follow.

6.1.4.2.1 Neutralization/Precipitation (Option A)

The underdrain collection system would discharge directly into an aeration pond where the carbonates and bicarbonates in the leachates (and ground water) are aerated. Aeration of carbonates and bicarbonates should reduce the lime requirement for precipitation and also reduce the amount of sludge generated from precipitation. In addition, aeration would remove any volatile organic compounds present in the surface leachate seeps (and ground water).

The aeration pond has been designed to have a 30-minute residence time for an influent stream of 495 gpm. The basin would have a depth of 5 feet and cover an area of 400 square feet.

Construction of the aeration pond should allow a freeboard of 1 foot. A 1-foot clay liner of compacted clay overlain by a geomembrane liner would make up the bottom of the pond. The geomembrane should minimize the collected water from leaching from the pond. The clay liner provides an assurance of continued protection should the geomembrane fail. An underdrain system would be constructed under the clay liner of the pond for the purpose of collecting any leachate from the pond.

The water from the aeration basin would then be transferred to a settling basin through a channel, where a lime slurry would be added. The hydrated lime system would receive, store, and feed the hydrated lime to the channel. The system consists of a storage silo to store the powdered hydrated lime, a variable screw feeder to introduce powdered hydrated lime into the slaker at the desired rate, a lime slaker where the lime slurry would be prepared by mixing the hydrated lime with water, and a lime slurry storage tank, pumps, and control system. The system should be able to handle an average of 2.1 tons per day of hydrated lime (on a dry basis).

The settling pond should have a 2-day residence time to allow settling of the metal hydroxides, calcium sulfate formed from reaction between the lime feed and sulfates in the water, and suspended total solids. The settling pond would have a depth of 10 feet and a freeboard of 5 feet. The settling pond would cover an area of 0.44 acre.

A 1-foot clay liner of compacted clay overlain by a geomembrane liner will make up the bottom of the settling pond. The geomembrane will minimize the collected water from leaching from the pond. The clay liner provides an assurance of continued protection should the geomembrane fail. An underdrain system will be constructed under the clay liner of the pond for the purpose of collecting any leachate from the pond.

The treated water from the settling pond would discharge into Little McMahon Creek through a riprap-lined channel. The riprap-lined channel would be trapezoidal with side slopes of 2.5:1, a base width of 1-foot, and a depth of 5 feet.

Moisture control placement, and spreading of the aeration and settling pond materials should be QA/QC monitored to ensure compaction requirements of the pond materials are met. QA/QC testing should consist of fill and borrow material classification, moisture-density testing during the placement of the 6-inch lifts, field permeability testing with an infiltrometer, and laboratory testing of permeability from Shelby tubes taken of materials used in the pond construction and the geomembrane placed over the clay layer. The geomembrane should be checked for rips, punctures, and a proper seal of seams during placement.

To allow removal of the settled sludge, a second settling pond having the same design features as the one described above would be constructed. This pond may also be used in parallel with the first one during high flow seasons. Removal of the sludge would proceed as follows: while the sludge from the second pond is removed, the first pond would receive the surface leachate seeps (and also ground water) for treatment. Contents of the second pond would be pumped periodically (e.g., once a year) to a dewatering device (e.g., filter press) and the concentrated sludge from the dewatering device would be transported to a hazardous waste landfill for disposal and the clear liquid would be pumped to the first pond.

6.1.4.2.2 Constructed Wetlands (Option B)

The underdrain collection system will discharge into a limestone channel at the southern end of the landfill cap for the purpose of increasing the pH of the leachate (and also ground water) to approximately 6.5 and treating elevated levels of volatile organic chemicals. The riprap-lined channel should have a base width of 1 foot, a depth of 1/2 foot, and side slope of 2.5:1. The channel would be lined with a 24-inch thick blanket of graded (d_{50} = 12 inches) limestone rock. A cover on the limestone channel would be necessary to avoid formation of ferric hydroxide, which would deactivate the limestone.

The riprap-lined channel would discharge to a cattail wetland. The most important metal removing mechanisms in the wetland are the bacterially-catalyzed oxidation and hydrolysis reactions that cause dissolved iron to precipitate. Also, BOD and COD are remediated in the wetland. Another potentially important mechanism is bacterial sulfate reduction, which goes on in the anaerobic organic substrate. The sulfide ion reacts with the organic mass. More important, this reaction consumes acidity and raises the pH of the water. Potential removal of metals by the organic substrates in the wetland through adsorption and chelation is limited.

The size of the wetland is expected to be approximately 9 acres. Because this is an innovative technology, a 100 percent contingency has been added to account for unexpected high loadings. Considering this contingency, the size would be 9-18 acres. The actual sizing of the treatment system is subject to the results of remedial design and treatability investigations. The maximum size has been used in costing for comparison purposes, only. The design would include construction of a maximum of six cells, each 3 acres in size.

The clean water from cattail treatment would be discharged to Little McMahon Creek.

It has been assumed that sludge will eventually build up in the wetland that would require dredging of part of the wetland every 15 years. For costing purposes, it was assumed that the sludge from 2 cells (6 acres) is dredged and hauled off site for disposal as municipal waste each 15 years.

6.1.4.3 Monitoring of Surface Leachate Seeps

In addition to monitoring of surface leachate seeps (at L-1, L-2, L-4, L-5 and other leachates which may be discovered during RD/RA activities) at their respective sources, the combined surface leachate seeps collected by the underdrain system and ground water would be sampled three times per year, twice under dry conditions and once under wet conditions. Specific sampling frequencies will be determined during RD/RA activities. Sampling frequencies cited in this FS Report are for cost estimating purposes only. Samples would be collected at the discharge to treatment and should be analyzed for volatile and semivolatile organic compounds and heavy metals. In addition, the effluent from treatment would be sampled three times per year and be analyzed for the same parameters as the untreated surface leachate seeps.

6.2 Evaluation of Remedial Alternatives

Remedial alternatives are evaluated with respect to (1) effectiveness, (2) implementability, and (3) cost. This evaluation was conducted to screen the alternatives prior to a detailed analysis.

Effectiveness Evaluation This evaluation focuses on (1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the remediation goals identified in the remedial action objectives, (2) the potential impacts to human health and the environment during the construction and implementation phase, and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site.

The wetland should have a 1-foot base of compacted clay overlain by a geomembrane to minimize the loss of leachate into the underlying soil. The geomembrane liner would be overlain by 6 inches of sand (SP or finer), then 1 foot of crushed limestone aggregate. The limestone is then covered with 1 foot of spent mushroom compost. Cattails would be planted in the substrate. Bottom slopes would vary from 1 to 3 percent. Flow paths would be established using hay bales. The hay bales should maximize the effective retention time and avoid channelization or short-circuiting of the cells until the cattail population is well established. Required maintenance for the wetland will be determined during RD activities. Depth of water in the cells will vary between 6 and 12 inches. With continuous flow of ground water, problems due to freezing are not considered critical to wetland performance (if properly sized). Dikes would be constructed with 18 to 30 inches of freeboard to ensure at least a 1-foot freeboard over the long term.

Implementability Evaluation Implementability encompasses both the technical and administrative feasibility of implementing a technology process. This evaluation is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for off-site actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology.

Cost Evaluation In this evaluation, the cost analysis is made on the basis of the detailed cost estimates provided in Appendix B.

The evaluations of each alternative 1 through 4 are discussed in Sections 6.2.1 through 6.2.4 and summarized in Section 6.3.

6.2.1 Alternative 1: No Action

Alternative 1 considers that no remedial actions will be implemented at the BRL site beyond placement of final cover over the Waste Pit and the landfill as part of the landfill closure (which is beyond the scope of this work). Evaluation of Alternative 1 using the three criteria is presented below:

6.2.1.1 Effectiveness

Alternative 1 is not effective as it fails to meet any of the remedial objectives of the BRL site.

6.2.1.2 Implementation

No implementation is involved as no remedial actions are taken.

6.2.1.3 Costs

Alternative 1 has no associated costs as it does not involve any remedial actions.

6.2.2 Alternative 2: Institutional Actions

Alternative 2 involves the following major components:

- Deed restrictions
- Fencing
- Ground-water monitoring
- Surface leachate seep monitoring
- Monitoring of Kings Run

Evaluation of Alternative 2 using the three criteria is presented below.

6.2.2.1 Effectiveness

The results of the Endangerment Assessment showed that in its present condition the site poses risks to human health and the environment from current exposure scenarios (for dirt bikers or trespassers at the site). Risks from future worst-case exposure scenarios would be significant due only to water quality conditions caused by leaching from the site.

Dirt bikers and trespassers, by definition, are already in violation of local ordinance and would likely not be deterred from entering the site, even if fenced. Also, the alternative is ineffective because it does not address ground-water/surface water pathways.

6.2.2.2 Implementability

Institutional Actions are readily implementable. The requirements and procedures for monitoring are well established, routine practices for environmental consulting firms and laboratories.

6.2.2.3 Cost

The total project cost for Alternative 2, Institutional Action, is estimated to be approximately 1,786,000. As is apparent from the cost breakdown summary for Alternative 2 presented below, the only cost associated with this alternative is that for fencing and ongoing monitoring of site surface water, ground water, and leachate seeps.

Alternative 2A

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$226,000	$106,000	30 Years	$1,786,000

6.2.3 Alternative 3: RCRA Cap

Alternative 3 involves the following major components:

- Full RCRA cap
- Deed restrictions
- Fencing
- Ground-water collection
- Surface leachate seep collection
- Ground-water monitoring
- Surface leachate seep monitoring
- Monitoring of Kings Run
- Water treatment by neutralization/precipitation (Option A only)
- Water treatment by constructed wetlands (Option B only)

The evaluation of Alternative 3 using the three criteria is presented below.

6.2.3.1 Effectiveness

This alternative is effective in controlling access to the site through fencing, potentially reducing exposure to unauthorized people.

During site remediation, this alternative involves excavation and grading of approximately 11 million cubic yards of material and could increase exposure of the on-site workers to hazardous materials through dust inhalation. However, this exposure could be minimized through dust control measures. Transport of approximately 393,700 cubic yards of clay borrow material for the cap construction may cause fugitive dust emissions but can be controlled through dust suppressants.

The effectiveness of the RCRA cap has been well documented on hazardous waste sites. This alternative would cut off the source of recharge to the Waste Pit and the water-bearing zones potentially in contact with it, thus preventing any future mobilization of the Waste Pit contaminants into ground water or surface leachate seeps.

Ground water and surface leachate seep collection methods selected for Alternative 3 (French drains and underdrains) involve well established technologies. Treatment of these waters by either neutralization/precipitation or wetlands will produce an immediate benefit by significantly reducing the quantity and concentration of the contaminants of concern that migrate off site. The neutralization/precipitation option can be tailored to improve effluent quality, whereas, fine control over effluent quality may not be as effective for the wetlands. The sludge generated from neutralization/precipitation would be disposed of at a hazardous waste landfill. Sludges from wetlands treatment will be tested to determine if they are hazardous on nonhazardous, and disposed of appropriately. For costing purposes, the sludges are assumed to be nonhazardous waste that is transported to an off-site landfill.

6.2.3.2 Implementability

Installation of a RCRA cap requires extensive amount of preparatory cut and fill of on-site material (approximately 11 million cubic yards) to meet the stringent slope requirements of the cap. However, the RCRA design has been a well proven technology. Furthermore, implementation of a RCRA cap is expected to take a minimum of 30 months. This schedule may be delayed based on weather conditions as well as construction-related factors. In addition, Alternative 3 would require installation of double pipes to contain Kings Run, making implementation of this alternative more difficult than some of the others.

The proposed ground water and surface leachate seep collection technologies would be readily implementable at the BRL site. Implementation of the ground water and surface leachate seep treatment by precipitation/neutralization would also be readily implementable. Sufficient area is available for the construction of this option. As wetlands treatment requires more space (approximately 9-18 acres), site topography needs to be carefully evaluated during the remedial design phase. If Alternative 3 is selected, the maximum size of the wetlands would be 9 acres due to the grading requirements for the RCRA cap.

6.2.3.3 Cost

Costs associated with Alternative 3 (in dollars) for water treatment options A and B are shown below. The capital cost includes direct capital for the equipment, labor, and materials necessary for the installation of the RCRA cap, leachate collection system, fence, and water treatment system. Indirect capital costs for engineering and other contingencies are also included in this figure.

Annual costs for this alternative includes operation, maintenance, and sampling. Total present net worth values of all costs include a 20 percent preliminary estimate contingency, and future costs are based on a 5 percent discount rate. All costs presented below are rounded to the nearest $1,000. The total net present value for Alternative 3B includes wetlands dredging and revegetation in years 15 and 30. Cost estimate details are presented in Appendix B.

Alternative 3A

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$184,745,000	$834,000	30 Years	$196,913,000

Alternative 3B

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$191,227,000	$153,000	30 Years	$193,084,000

6.2.4 Alternative 4: Standard Landfill Cap

The major components of Alternative 4 are:

- Standard landfill cap
- Deed restrictions
- Fencing
- Ground-water collection
- Surface leachate seep collection
- Ground-water monitoring
- Surface leachate seep monitoring
- Monitoring of Kings Run
- Water treatment by neutralization/precipitation (Option A only)
- Water treatment by constructed wetlands (Option B only)

Evaluation of the three criteria for Alternative 4 is presented below.

6.2.4.1 Effectiveness

This alternative is effective in controlling access to the site through fencing, potentially reducing exposure to unauthorized people during on-site activities.

During site remediation, this alternative involves excavation grading of approximately 1.3 million cubic yards of material, which could cause potential exposure of the on-site workers to hazardous materials through dust inhalation. Potential exposure of the on-site workers would be approximately one-eight of that for Alternative 3. Potential exposure could be minimized through dust control measures and respiratory protection.

Transport of approximately 280,720 cubic yards of clay borrow material for the cap construction may cause fugitive dust emissions, but could be controlled through dust suppressants. The quantity of material transported is approximately 29 percent less than that required under Alternative 3.

The standard landfill cap is as effective as the RCRA cap as it would cut off the source of recharge to the Waste Pit and the water-bearing zones potentially in contact with it, thus preventing any future mobilization of the Waste Pit contaminants into ground water or surface leachate seeps. The effectiveness of the standard landfill cap has been well documented on nonhazardous landfill sites.

Ground water and surface leachate seep collection methods selected for Alternative 4 (French drains and underdrains) involve well established technologies. Treatment of these waters by either neutralization precipitation or wetlands will produce an immediate benefit by significantly reducing the quantity and concentration of the contaminants of concern that migrate off site. The neutralization/precipitation option can be tailored to improve effluent quality, whereas, fine control over effluent quality may not be as effective by the wetlands. Furthermore, the sludge generated from neutralization/precipitation is disposed of at a hazardous waste landfill. Precipitates from wetlands treatment will be tested to determine if they are hazardous or nonhazardous, and disposed of appropriately. For costing purposes, the sludges are assumed to be nonhazardous waste that is transported to an off-site landfill.

6.2.4.2 Implementability

Installation of a standard landfill cap at the site is more readily implementable than the RCRA cap because of lower requirements for preparatory cut and fill of on-site material (this results from lower slope requirements).

The quantity of fill material is estimated to be approximately one-eight of that needed under Alternative 4. Furthermore, implementation of Alternative 4 takes much less time than Alternative 3 (18 months versus 30 months depending on weather conditions as well as construction-related factors).

The proposed ground water and surface leachate seep collection technologies are readily implementable at the BRL site. Implementation of the ground water and surface leachate seep treatment by precipitation/neutralization can also be readily implementable. Sufficient area is available for the construction of this option. As wetlands treatment requires more space (approximately 9-18 acres), site topography needs to be carefully evaluated during the remedial design phase.

6.2.4.3 Cost

Costs associated with Alternative 4 (in dollars) for water treatment options A and B are shown below. The capita cost includes direct capital for the equipment, labor, and materials necessary for the ir ation of the standard landfill cap, monitoring both the leachate and ground water, lea ate collection system, ground water collection system, fence, and water treatment system. Indirect capital costs for engineering and other contingencies are also included in this figure.

The annual cost for this alternative includes operation, maintenance, and sampling costs. Total present net worth values of all costs include a 20-percent preliminary estimate contingency, and future costs are based on a 5-percent discount rate. All costs presented below are rounded to the nearest $1,000. The total net present value for alternative 4B includes wetlands dredging and revegetation in years 15 and 30. Cost estimate details are presented in Appendix B.

Alternative 4A

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$40,447,000	$780,000	30 years	$52,492,000

Alternative 4B

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$46,923,000	$99,000	30 years	$48,663,000

6.3 Alternatives Screening

The purpose of the alternative screening process is to narrow the list of the potential remedial actions to be carried forward for detailed analysis, if necessary (NCP, Section 300.68(g)). The NCP further : ·es that the three broad criteria to be used in the screening of the alternatives b. · ·ectiveness, implementability, and cost.

Among the four alternatives considered for the BRL site, Alternative 2 was eliminated from further consideration based on discussions presented in Section 6.2. Alternatives 2 is ineffective because it does not meet the remedial objectives for the BRL site. At a minimum, Alternative 2 does not immobilize contaminants in the future because the recharge areas of the water-bearing zones are not covered by a cap.

Alternatives 3 and 4 pass all three criteria of evaluation (i.e., effectiveness, implementability, and cost) and are retained for detailed analysis. Both alternatives are responsive to the remedial objectives for the site, protective of human health and the environment, and meet or exceed state and federal ARARs. These alternatives can also both be implemented at the BRL site. In addition, Alternative 1 (the No Action alternative) is retained through the detailed analysis of alternatives, as required by NCP, to provide a baseline of comparison with the other alternatives.

7.0 DETAILED ANALYSIS OF ALTERNATIVES

7.1 Introduction

The detailed analysis of alternatives consists of the evaluation and presentation of the relevant information needed to allow the Agencies to select a site remedy. In the detailed analysis, each alternative is assessed against nine evaluation criteria described below. The results of this assessment are arrayed to compare the alternatives and identify the key tradeoffs among them. This approach to analyzing alternatives provides the Agencies with sufficient information to adequately compare the alternatives, select an appropriate remedy for the site, and demonstrate satisfaction of the CERCLA remedy selection requirements in the Record of Decision (ROD).

The nine criteria for evaluating remedial alternatives are as follows:

- Overall protection of human health and the environment
- ARARs compliance
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- State acceptance
- Community acceptance

The first seven criteria are strictly technical issues. The last two, state acceptance and community acceptance, are reserved for EPA and OEPA (the Agencies). The nine evaluation criteria that are defined and described in detail below. A summary of the comparison of alternatives is presented later in this chapter.

7.1.1 Overall Protection of Human Health and The Environment

This provides a final check to assess whether each alternative adequately protects human health and the environment as well as a description of how risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

7.1.2 Compliance with ARARs

This discusses whether alternatives will meet all federal and state applicable or relevant and appropriate regulations (ARARs) previously identified in the RI/FS process. When an alternative meets ARARs, then this criteria describes how it does. When an

ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA is discussed. Three types of ARARs have been identified for the BRL site:

- Chemical-specific ARARs
- Action-specific ARARs
- Location-specific ARARs

7.1.3 Short-term Effectiveness

This criterion addresses the effects of the alternatives during the construction and implementation phase until remedial objectives are met. Alternatives are evaluated with respect to their effects on human health and the environment, if applicable, during implementation of the remedial action.

The following factors will be evaluated under short-term effectiveness:

- Protection of the community during remedial actions
- Protection of the workers during remedial actions
- Environmental impacts of the remedial action
- Time lapse before achievement of response objectives

7.1.4 Long-term Effectiveness and Permanence

This addresses the results of a remedial action in terms of the risk remaining at the site after remedial objectives are met. Any controls required to manage the risk posed by treatment residuals or untreated wastes are described. The three components of this criterion that will be addressed for each alternative are:

- Magnitude of remaining risk
- Adequacy of long-term controls
- Reliability of long-term controls

7.1.5 Reduction of Toxicity, Mobility, or Volume

This criterion addresses the statutory preference for selecting remedial actions employing treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances. This evaluation will focus on:

- The amount and types of hazardous materials that will be destroyed or treated
- The degree of expected reduction in toxicity mobility and volume
- The degree of irreversibility of the process

- The type and quantity of residuals remaining following treatment

7.1.6 Implementability

At this stage of the feasibility study process, the technologies comprising the alternatives presented here have already undergone implementability analysis. In this final analysis, implementability of the screened alternatives will be further defined, if possible, considering all technologies which comprise each alternative. This implementability evaluation involves both technical and administrative feasibility of the alternative and the availability of various services and materials required during its implementation. Technical feasibility addresses construction and operational concerns and the reliability of technologies used. Administrative feasibility addresses activities needed to coordinate with Agencies (e.g., obtaining permits).

7.1.7 Cost

The cost estimates presented for the surviving alternatives are the same as presented in Section 6.2 and have been reiterated here for the sake of continuity. The cost analyses presented consist of detailed, dollar estimates of each alternative. These costs are based upon the site-specific data, and were determined by using standard engineering cost estimation guides and vendor quotes. The dollar values of the alternatives developed for this study are intended to be estimates with an accuracy of +50 to -30 percent. This criterion addresses how total alternative costs, stated in present worth dollars including capital and operation and maintenance (O&M) expenses, compare to one another.

7.1.8 State Acceptance

This assessment evaluates the technical and administrative issues and concerns that the State Agency may have regarding each of the remedial alternatives. Evaluation of state acceptance is reserved for the Agencies.

7.1.9 Community Acceptance

This assessment evaluates the issues and concerns that the public may have regarding each of the alternatives. The evaluation of this criteria is reserved for the Agencies.

7.2 Individual Analyses

The analysis of individual alternatives with respect to the first seven of the nine criteria is discussed below. Evaluation of community and state acceptance is reserved for the Agencies. Once each remedial alternative has been described and individually assessed against the criteria, a comparative analysis is presented evaluating the relative performance of each alternative relative to each specific criterion. Up to this point in the FS process, each alternative was analyzed independently without consideration of other alternatives. The comparative analysis identifies key tradeoffs among alternatives useful to the Agencies during remedy selection. Detailed analysis of Alternatives 3 and 4 are presented in the following subsections and compared in Section 7.3.

7.2.1 Alternative 3: RCRA Cap

Alternative 3 involves the following major components:

- Full RCRA cap
- Deed restrictions
- Fencing
- Ground-water collection
- Surface leachate seep collection
- Ground-water monitoring
- Surface leachate seep monitoring
- Monitoring of Kings Run
- Water treatment by neutralization/precipitation (Option A only)
- Water treatment by constructed wetlands (Option B only)

The evaluation of Alternative 3 using the remaining seven criteria is presented below.

7.2.1.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is provided by Alternative 3. The long-term effectiveness should be excellent. The excavation of soils on site presents short-term risks to workers and the surrounding population, but these exposure risks could be minimized through the use of dust control measures during earthworking processes and the employment of proper personal protective equipment (PPE) for site workers, when needed. Once the RCRA cap were in place, Alternative 3 would effectively reduce the infiltration of rainwater through all of the waste material, and eliminate human contact with the capped waste. Although the cap itself would provide no permanent reduction of the toxicity, mobility, or volume of the contaminants found in the soil matrix, both water treatment options provide a reduction of mobility and volume of the waste.

It is projected that Alternative 3 would be able to meet the cleanup requirements for the site, as well as federal and state ARARs.

7.2.1.2 ARARs Compliance

CERCLA 121(d)(2) requires that superfund actions comply with other laws that are ARARs. Alternative 3 would be able to meet the remedial action goals for the site. including ARARs for the site.

Action specific ARARs regarding fugitive dust emissions will be met by controlling these emissions through the use of dust suppressants. The cap would meet recommended and regulated minimum design standards at both the state and federal level and consistent with U.S. EPA guidance entitled "Minimum Technology Guidance for Final Covers on Hazardous Waste Landfills and Surface Impoundment". The cap and leachate collection system should effectively eliminate the migration of contaminants to off-site surface water.

Chemical specific ARARs regarding air emissions from the leachate treatment system will be met. Discharge from the treatment system will not exceed the limits determined for the site during the NPDES permit process.

7.2.1.3 Short-Term Effectiveness

Protection of the community during implementation of the remedial action could be accomplished under Alternative 3. Site access control would be maintained during any remedial action to restrict entry of (and thus, reduce potential exposure to) unauthorized personnel.

Alternative 3 would require the excavation/grading of approximately 11 million cubic yards of material to implement the remedial technologies. This grading of material could produce airborne contaminants through the stirring of dust and contaminated soils on site: these contaminants are potential hazards to workers on site and to nearby residents. Dust control methods would therefore be employed, if necessary, to minimize the transfer of contaminated soils into the air from construction related activities.

The transport of approximately 393,700 cubic yards of clay borrow material may also be a source for uncontaminated fugitive dust emissions, but these emissions could also be controlled through the use of a dust suppressant.

If monitoring indicates it is necessary, workers would be protected during initial earth moving activities through the use of Level C PPE to further reduce the threat of airborne contaminants. PPE to Level A or Level B would be implemented, if necessary.

The implementation of the alternative utilizing either water treatment option A or B is not expected to have a significant detrimental impact on the environment. and would produce an immediate environmental benefit by significantly reducing the quantity and concentration of the contaminated waste/leachate that migrates off site.

7.2.1.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk under Alternative 3 should be lowered due to the physical separation of the contaminated soils from human receptors and the environment that is provided by the cap. In the unlikely event of RCRA cap failure, the risk from residual waste on site would be small due to the leachate collection and treatment system utilized under water treatment options A and B for the alternative.

The adequacy and reliability of RCRA capping systems are well documented on hazardous waste sites. This alternative would cut off the source of recharge to the Waste Pit and the water-bearing zones potentially in contact with it, thus, preventing any future mobilization of the Waste Pit contaminants into ground water or surface leachate seeps. The stringent sloping requirements and multiple low permeability layers of the RCRA cap in Alternative 3 increase the performance and reliability of the entire system. The reliable life expectancy of the RCRA cap with normal maintenance is approximately 50 to 100 years. After this period of time, more extensive maintenance and repair procedures may have to be undertaken to restore the effectiveness of the cap.

The drainage channels in Alternative 3 would require periodic inspection for erosion or other forms of degradation. The inlet and outlet of Kings Run would also be inspected for degradation regularly. The pipe run also requires inspection for silting/blockage.

Routine cap maintenance would be limited to periodic cap inspection and mowing of the vegetative layer as needed. Any signs of unexpected settling or subsidence will be addressed immediately upon discovery.

Surface-water treatment Option A (chemical treatment of the stream) is a well-proven means of water treatment. The use of lime to neutralize a waste stream and precipitate metal contaminants is a commonly employed technology for the remediation of metal-contaminated waste streams and acid mine drainage. Before a waste-specific treatability study is performed using the technology, however, it is uncertain exactly what effluent quality could be achieved using this method. The chemical treatment option is flexible, however, and thus could be tailored or modified to improve effluent quality if necessary.

Surface-water treatment Option B (the constructed wetland technology) has been demonstrated in the treatment of acid mine drainage. As with the chemical treatment option, it is unknown what level of effluent quality can be achieved using this technology. The passive treatment associated with the constructed wetland option, however, does not allow for the fine control over effluent quality that is possible with a chemical treatment system. The sludge generated from neutralization precipitation is disposed at a hazardous waste landfill. Precipitates from wetlands treatment will be tested to determine if they are hazardous or nonhazardous, and disposed of appropriately. For costing purposes, the sludges are assumed to be nonhazardous waste that is transported to an off-site landfill.

7.2.1.5 Reduction of Toxicity, Mobility, or Volume

The construction of a RCRA cap would reduce the potential of exposure to the contaminants, but does not result in the reduction of toxicity, mobility, or volume of the landfilled material. The cap would reduce the volume of leachate produced, however, by effectively minimizing infiltration of rainwater. The mobility of the contaminants would also be reduced through this reduction in infiltration.

The construction of the leachate collection system in Alternative 3 would limit the migration of contaminants into the ground water and would reduce the risk for human contact with the contaminants, but does not result in a reduction of the toxicity, mobility, or volume of the waste.

Both water treatment options A and B result in a reduction of volume and mobility of the contaminants. The treatment systems are designed to treat approximately 3 million gallons of leachate per day. Water treatment option A would produce an unknown quantity of sludge along with the process that will need disposal; treatment option B also results in the formation of sludge. For costing purposes, it has been assumed that the sludge generated by treatment option B (wetlands) is nonhazardous and is transported to an off-site landfill for disposal. The sludge will be tested to determine whether it is hazardous or nonhazardous, and disposed of appropriately.

7.2.1.6 Implementability

Alternative 3 is implementable with some difficulty at the BRL site. Installation of the RCRA cap does require the grading of an extensive amount of material (approximately 11 million cubic yards) to meet the stringent slope requirements of the cap. In addition, Alternative 3 would require installation of double pipes to contain Kings Run, making implementation of this alternative difficult.

The technologies of excavation and capping have been well proven, and have been extensively practiced on hazardous waste sites in the past. Additional remedial actions, if necessary, would be difficult on the capped portions of the site, and will most likely require the removal of a portion of the cap.

Implementation of a RCRA cap would be expected to take a minimum of 30 months. This schedule may be delayed based on weather conditions as well as construction-related factors. The materials, equipment, and services necessary for the construction are available for all aspects of the alternative.

The proposed ground water and surface leachate seep collection technologies are readily implementable at the BRL site. Implementation of the ground water and surface leachate seep treatment by precipitation/neutralization can also be readily implementable. Sufficient area is available for the construction of this option. As wetlands treatment requires more space (approximately 9-18 acres), site topography needs to be carefully evaluated during the remedial design phase. If Alternative 3 is selected, the maximum site of the wetland would be 9 acres, due to the grading requirements for the RCRA cap.

The administrative implementability of Alternative 3 is also expected to be good. The discharge of treated water would require coordination with and approval from the OEPA through the NPDES program. Final design of the alternative should also be coordinated with the ODNR Division of Reclamation; the reclamation to the west of the site is under ODNR's jurisdiction.

7.2.1.7 Cost

Costs associated with Alternative 3 (in dollars) for water treatment options A and B are shown below. The capital cost includes direct capital for the equipment, labor, and materials that would be necessary for the installation of the RCRA cap, leachate collection system, fence, and water treatment system. Indirect capital costs for engineering and other contingencies are also included in this figure.

Annual costs for this alternative would include operation, maintenance, and sampling. Total present net worth values of all costs include a 20 percent preliminary estimate contingency, and future costs are based on a 5 percent discount rate. All costs presented below are rounded to the nearest $1,000. The total net present value for Alternative 3B includes wetlands dredging and revegetation in years 15 and 30. Cost estimate details are presented in Appendix B.

Alternative 3A

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$184,745,000	$834,000	30 years	$196,913,000

Alternative 3B

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$191.222.000	$153.000	30 years	$193.084.000

7.2.3 Alternative 4: Standard Cap

The major components of Alternative 4 are:

- Standard landfill cap
- Deed restrictions
- Fencing
- Ground-water collection
- Surface leachate seep collection
- Ground-water monitoring
- Surface leachate seep monitoring
- Monitoring of Kings Run
- Water treatment by neutralization/precipitation (Option A only)
- *Water treatment by constructed wetlands (Option B only)*

Evaluation of the seven criteria for Alternative 4 are presented below.

7.2.3.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is provided by Alternative 4. The long-term effectiveness of Alternative 4 is very good. The excavation of soils on site presents short-term risks to workers and the surrounding population, but these exposure risks could be minimized through the use of dust control measures during earthworking processes and the employment of proper personal protective equipment (PPE) for site workers, when needed. Once the cap is in place, Alternative 4 would effectively reduce the infiltration of rainwater through all of the waste material, and would eliminate human contact with the capped waste. Although the cap itself would provide no permanent reduction of the toxicity, mobility, or volume of the contaminants found in the soil matrix, both water treatment options provide a reduction of mobility and volume of the waste.

It is projected that Alternative 4 would be able to meet the cleanup requirements for the site, as well as federal and state ARARs.

7.2.3.2 ARARs Compliance

CERCLA 121(d)(2) requires that Superfund actions comply with other laws that are ARARs. Alternative 4 should be able to meet the remedial action goals for the site, including ARARs for the site.

Action specific ARARs regarding fugitive dust emissions would be met by controlling these emissions through the use of dust suppressants. The cap would meet recommended and regulated minimum design standards at both the state and federal level. At a minimum, the cap would meet applicable, relevant, and appropriate sanitary landfill design standards at both state and federal levels. The cap and leachate collection system should effectively eliminate the migration of contaminants to off-site surface water.

Chemical specific ARARs regarding air emissions from the leachate treatment system will be met. Discharge from the treatment system should not exceed the limits determined for the site during the NPDES permit process.

7.2.3.3 Short-Term Effectiveness

Protection of the community during implementation of the remedial action can be accomplished under Alternative 4. Site access control would be maintained during any remedial action to restrict entry of (and thus, reduce potential exposure to) unauthorized personnel during on-site RA activities.

Alternative 4 would require the excavation/grading of approximately 1.3 million cubic yards of material to implement the remedial technologies. This grading of material could produce airborne contaminants through the stirring of dust and contaminated soils on site; these contaminants are potential hazards to workers on site and to nearby residents. Dust control methods would therefore be employed, if necessary, to minimize the transfer of contaminated soils into the air from construction related activities.

The transport of approximately 280,720 cubic yards of clay borrow material may also be a source for uncontaminated fugitive dust emissions, but these emissions could also be controlled through the use of a dust suppressant.

If monitoring indicates it is necessary, workers would be protected during initial earth moving activities through the use of Level C PPE to further reduce the threat of airborne contaminants. PPE to Level A or Level B would be implemented if necessary.

The implementation of the alternative utilizing either water treatment option A or B is not expected to have a significant detrimental impact on the environment, and should produce an immediate environmental benefit by significantly reducing the quantity and concentration of the contaminated waste leachate that migrates off site.

7.2.3.4 Long-Term Effectiveness and Permanence

The magnitude of residual risk under Alternative 4 would be lowered due to the physical separation of the contaminated soils from human receptors and the environment that is provided by the cap. In the event of cap failure, the risk from residual waste on site would be small due to the leachate collection and treatment system utilized under water treatment options A or B for the alternative.

The adequacy and reliability of standard landfill capping systems are well documented. The reliable life expectancy of the standard landfill cap with normal maintenance is approximately 50 to [illegible] years. After this period of time, more extensive maintenance and repair procedures may have to be undertaken to restore the effectiveness of the cap.

Routine cap maintenance would be limited to periodic cap inspection for signs of erosion, settlement and subsidence, and mowing of the vegetative layer as needed. Any signs of unexpected settling or subsidence in the cap should be addressed immediately. The drainage channels would also require periodic inspection for erosion or other forms of degradation, as well.

Surface water treatment option A, chemical treatment of the stream, is a well-proven means of water treatment. The use of lime to neutralize a waste stream and precipitate metal contaminants is a commonly employed technology for the remediation of metal-contaminated waste streams and acid mine drainage. Before a waste-specific treatability study is performed using the technology, the effluent quality that can be achieved should be determined. It should be recognized that the resulting effluent quality is presently unknown. The chemical treatment option is flexible, however, and thus could be tailored or modified to improve effluent quality if necessary.

Surface-water treatment Option B (the constructed wetland technology) has been demonstrated in the treatment of acid mine drainage. As with the chemical treatment option, it is unknown what level of effluent quality can be achieved using this technology. The passive treatment associated with the constructed wetland option, however, does not allow for the fine control over effluent quality that is possible with a chemical treatment system. The sludge generated from neutralization/precipitation is disposed at a hazardous waste landfill. Precipitates from wetlands treatment will be tested to determine if they are hazardous or nonhazardous, and disposed of appropriately. For costing purposes, the sludges are assumed to be non-hazardous waste that is transported to an off-site landfill.

7.2.3.5 Reduction of Toxicity, Mobility, or Volume

The construction of a standard landfill cap would reduce the potential of exposure to the contaminants, but does not result in the reduction of toxicity, mobility, or volume of the landfilled material. The cap would reduce the volume of leachate produced, however, by effectively minimizing infiltration of rainwater. The mobility of contaminants would also be reduced through this reduction in infiltration.

The construction of the leachate collection system in Alternative 4 would limit the migration of contaminants into the ground water and would reduce the risk for human contact with the contaminants, but does not result in a reduction of the toxicity, mobility, or volume of the waste.

Both water treatment options A and B results in a reduction of volume and mobility of the contaminants. The treatment systems are designed to treat approximately 3 million gallons of leachate per day. Water treatment option A would produce an unknown quantity of sludge along with the process that will need disposal; treatment option B also results in the formation of sludge. For costing purposes, it has been assumed that the sludge generated by treatment option B (wetlands) is nonhazardous and is transported to an off-site landfill. The sludge will be tested to determine whether it is hazardous or nonhazardous, and disposed of appropriately.

7.2.3.6 Implementability

Alternative 4 is implementable at the BRL site. Implementation of the alternative would require the grading of a moderate amount of material (approximately 1.3 million cubic yards).

The technologies of excavation and capping have been well proven, and have been extensively practiced on hazardous waste sites in the past. Additional remedial actions, if necessary, would be difficult on the capped portions of the site, and will most likely require the removal of a portion of the cap. The effectiveness of the capping remedy could be readily established through the sampling and metering of the leachate following cap installation.

The proposed ground water and surface leachate seep collection technologies are readily implementable at the BRL site. Implementation of the ground water and surface leachate seep treatment by precipitation/neutralization can also be readily implementable. Sufficient area is available for the construction of this option. As wetlands treatment requires more space (approximately 9-18 acres), site topography needs to be carefully evaluated during the remedial design phase.

Implementation of Alternative 4 would expected to take a minimum of 18 months. This schedule may be delayed based on weather conditions as well as construction-related factors. The materials, equipment, and services necessary for the construction are available for all aspects of the alternative.

The administrative implementability of Alternative 4 is also expected to be good. The discharge of treated water would require coordination with an approval from the OEPA through the NPDES program. Final design of the alternative should also be coordinated with the ODNR Division of Reclamation since the reclamation to the west of the site under their jurisdiction.

7.2.3.7 Cost

Costs associated with Alternative 4 (in dollars) for water treatment options A and B are shown below. The capital cost includes direct capital for the equipment, labor, and materials that would be necessary for the installation of the standard landfill cap, leachate collection system, fence, and water treatment system. Indirect capital costs for engineering and other contingencies are also included in this figure.

The annual cost for this alternative would include operation, maintenance, and sampling costs. Total present net worth values of all costs include a 20 percent preliminary estimate contingency, and future costs are based on a 5 percent discount rate. All costs presented below are rounded to the nearest $1,000. The total net present value for Alternative 4B includes wetlands dredging and revegetation in years 15 and 30. Cost estimate details are presented in Appendix B.

Alternative 4A

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$40,447,000	$780,000	30 years	$52,492,000

Alternative 4B

Capital Cost	Annual O&M Cost	Duration	Total Present Net Worth
$46,923,000	$99,000	30 years	$48,663,000

7.3 Comparison Among Alternatives

The alternatives were assembled for the Buckeye Reclamation site have now been evaluated individually on seven criteria:

- Overall protection of human health and the environment
- ARARs compliance
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost

The other two criteria, state and community acceptance, are reserved for the Agencies.

In this section of the Feasibility Study report, the results of the detailed evaluation of the alternatives and remedial options will be used to compare among the different alternatives on the basis of the seven technical criteria. It is only through a comparison among the different alternatives that one can sense the relative benefits that one alternative may have over the others.

The purpose of this section, therefore, is to present the comparison in a way that will reveal relative performance benefits and drawbacks. Table 7-1 provides a summary of each alternative's relative performance according to the seven criteria. A detailed criterion-by-criterion comparison of the alternatives follows.

7.3.1 Overall Protection of Human Health and the Environment

All of the remedial alternatives proposed for application on the Buckeye Reclamation site are protective of human health and the environment except Alternative 1 (No Action). The alternatives that use a remedial action do differ somewhat, however, in the means employed to eliminate, reduce, or control the risks.

All of the proposed remedial alternatives reduce the risk of human exposure to contamination by using access restrictions to the site, a reduced permeability cap, and some form of water treatment. Whether option A (chemical treatment) or option B (constructed wetlands) are chosen, both will be designed and operated to meet the remedial action goals for the site.

TABLE 7-1

SUMMARY OF ALTERNATIVE EVALUATION

	Alternative	Overall Protection of Human Health and the Environment	ARAR Compliance	Short Term Effectiveness	Long Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Overall Implementability	Present Net Worth
1	No action	No	No	Poor	Poor	Poor	Fair	$0
3A	RCRA Cap Chemical Treatment of Leachates	Yes	Yes	Good	Excellent	Excellent	Fair good	196 913 000
3B	RCRA Cap Wetlands Treatment of Leachates	Yes	Yes	Good	Very good excellent	Excellent	Fair good	193,084 000
4A	Standard Landfill Cap 1 Chemical Treatment of Leachates	Yes	Yes	Excellent	Very good	Very good	Excellent	52,492 [illegible]
4B	Standard Landfill Cap Wetlands Treatment of Leachates	Yes	Yes	Excellent	Good very Good	Very good	Excellent	48 663 000

[illegible]

7.3.2 ARARs Compliance

All of the alternatives proposed for the Buckeye Reclamation site should be able to meet the site-specific ARARs with the exception of the No Action alternative.

7.3.3 Short-Term Effectiveness

The alternatives have similar impacts on short-term effectiveness because they involve the use of excavation/movement of soils during cap installation. The alternatives differ, however, with respect to the amount of excavation necessary as well as the length of time required to remediate the site. These factors present varying potential short-term risks associated with the alternatives during construction and implementation phases.

All alternatives (with the exception of the no action alternative) have good to excellent short-term effectiveness. Because of the large amount of excavation and fill required by alternatives 3A and 3B, alternatives 4A and 4B are rated higher for short-term effectiveness.

Alternative 1, the No Action alternative, has very few negative impacts in the short-term, but is not able to achieve the remedial action goals for the site.

7.3.4 Long-Term Effectiveness and Permanence

Alternatives developed for the Buckeye Reclamation site provide slightly different levels of long-term effectiveness and permanence. All alternatives provide infiltration protection, with Alternative 3A and 3B providing the most effective barrier, followed by Alternative 4A and 4B.

Among the water treatment options, option A (chemical treatment) provides the most flexibility and effectiveness due to its high level of controllability. Option B (constructed wetlands) is an innovative technology that has been shown to have varying levels of success.

Option A, chemical treatment, may require more frequent monitoring to assure effectiveness of the system as well as more frequent maintenance. The increased monitoring/maintenance may be balanced by the reliability/effectiveness of the treatment option. Option B, constructed wetlands, however, requires a much lower level of maintenance but has the uncertainty with regard to effectiveness. The No Action Alternative, of course, is the least effective of all the alternatives, and fails to achieve remedial action goals for the site.

7.3.5 Reduction of Toxicity, Mobility, and Volume

Section 121(b)(1) of the Comprehensive Environmental Response. Compensation, and Liability Act (CERCLA) of 1980 states that "remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants are a principal element, are to be preferred over remedial actions not involving such treatment." The alternatives utilize no such permanent treatment.

The comparisons and ranking of the alternatives with respect to reduction of toxicity, mobility, and volume of the contaminants results in an identical list of preferred alternatives that are favored for their long-term effectiveness and permanence. All alternatives provide for a reduction of the volume of acid mine drainage and mobility of the contaminants through the use of a low-permeability cap and a water treatment option. The No Action alternative, however, results in no decrease in toxicity, mobility, or volume.

Water treatment option A is more proven than option B and allows control over effluent quality. Option B is an innovative technology that has met with success in treating acid mine drainage in Ohio.

7.3.6 Implementability

The implementability of any alternative can be divided into technical and administrative implementability. These are compared for the different alternatives below.

Technical feasibility is the actual ability to implement the alternative from a technical standpoint. All of the alternatives for the Buckeye Reclamation site are technically implementable. The technologies, capacities, and manpower necessary to successfully operate the alternatives exist for each option.

The most difficult alternatives to implement from a technical basis are Alternatives 3A or 3B. The implementation of a RCRA cap on site is complicated by the varying topography of the site, and the extensive amount of earthwork needed to achieve the strict slope requirements of the cap. Alternative 4A and 4B (standard landfill cap) are the easiest to implement from a technical standpoint.

Option A is a more commonly used treatment technology because of assured effectiveness and the increased level of controllability of the system. Option B is an innovative technology that has shown of success in similar situations.

Administrative implementability is the feasibility of an alternative to attain the approval of the various regulatory agencies and other governing bodies necessary to implement the alternative. In contrast with the technical feasibility aspect of the alternatives, Alternative 3A and 3B may be the most administratively implementable alternative. The full RCRA cap provides a great amount of protection to the site, and thus would be the least likely to encounter administrative disapproval, however, technical feasibility clearly drives the ranking under this criteria.

Administrative approval of the No Action alternative is very unlikely, due to the risks that the site currently poses to human health and the environment.

7.3.7 Cost

The estimated present net worth of each alterna·   is given in Table 7-1. These costs are given assuming a 30-year water treatment time.

The array of costs presented shows Alternative 3 to be the most expensive alternative, followed by Alternative 4, and 1. This order remains constant when either option A or B for water treatment is chosen. There is an approximate difference of $148,414,000 between the least expensive (Alternative 4B) and most expensive (Alternative 3A) remedial alternative (not including the no cost, No Action alternative).

It is important to realize that one major factor (the cost of capping and grading activities) controls a large portion of the cost for some or all of the alternatives. If this parameter varies, the cost of a remedial action alternative may change dramatically.

APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) FOR THE BRL SITE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO ILLINOIS 60604

Received By
Metcalf & Eddy
JUL 05
Columbus, OH

REPLY TO THE ATTENTION OF:

5HS-11

03 JUL 1989

VIA OVERNIGHT MAIL

Mr. William C. Olasin
BRL - Project Manager
Ashland Chemical Company
P.O. Box 2219
Columbus, Ohio 43216

Re: Buckeye Reclamation Landfill

Dear Mr. Olasin:

Enclosed are the Applicable or Relevant and Appropriate Requirements (ARARs) and other factors to be considered (TBCs) which apply to the Buckeye Reclamation Landfill Feasibility Study (FS). This transmittal is made up of three parts: 1) joint agency comments on the draft preliminary scoping of potential remedial actions and an amended Alternatives Array Matrix (AAM), 2) U.S. EPA ARARs (water division ARARs are included in a separate document) and, 3) Ohio EPA ARARs. The amended AAM was used to obtain ARARs from the various divisions at U.S. EPA and the State of Ohio and will follow under separate cover.

Since the alternatives and technologies are presently in the development stage, additions to the ARARs and TBCs may occur. If the Agencies determine that other measures, not determined to be ARARs are necessary to protect public health and the environment, they will be part of the overall site remedy. Other types of requirements, such as monitoring, reporting, access, etc. will be included as part of remediation.

Remedial actions which are conducted entirely on-site will not require permits. The technical requirements and not the administrative requirements of any ARAR permits must be satisfied before the remedial action can be approved.

Following this transmittal will be a copy of the proposed Ohio Solid Waste Regulations which are currently TBCs and will be ARARS when final. If you have any questions regarding the ARARs and TBCs, please contact us.

Sincerely,

Ken Tindall
Remedial Project Manager
U.S. Environmental Protection Agency

Ken Tindall for
Brian J. Blair
Group Leader
Ohio Environmental Protection Agency

Enclosures

cc: David Graham, Chairman, BRL Steering Committee
Wesley Bradford, Versar, Inc.
Kathy Davidson, OCA-TSU, OEPA-CO

GENERAL STATUTORY AUTHORITIES

AIR

Some of the remedial action alternatives that could be selected for detailed evaluation could result in the release of particulate matter, toxic, and/or radioactive gases via the air pathway if implemented. Air ARARs stem from the Clean Air Act, and include substances regulated through the federally approved State Implementation Plan (SIP) and substances regulated under the Federal NESHAPS program and the New Source Performance Standards.

RCRA

The portions of the Resource Conservation and Recovery Act, as amended, which apply to this project are outlined in the alternative specific portion of this document. In general the RCRA regulations found in 40 CFR 264 Subparts C, F, G, N, and O apply, as well as 40 CFR 270 (incineration) and to a lesser extent, 40 CFR 262 and 263. For complete copies, you should refer to the applicable Code of Federal Regulations.

Water

The Clean Water Act and the Safe Drinking Water Act are the general federal statutes to refer to for federal water ARARs. MCLs, MCLGs, and AWQC, may be ARARs under CERCLA.

State

The generally pertinent State of Ohio statue is the Ohio Revised Code (ORC). ORC Chapter 3704 establishes Ohio EPA's authority to regulate and control air pollution within the State of Ohio. ORC Chapter 3734 provides statutory authority for the regulation of solid and hazardous waste activities in the State of Ohio. ORC Chapter 6111 establishes Ohio EPA's authority to set water quality standards and regulate water pollution sources. ORC 1521 and OAC 1501 regulate dams, dikes and levys. The State of Ohio regulations and rules developed on the basis of the ORC can be found in Chapter 3745 of the Ohio Administrative Code.

Environmental Media/ Remedial Technology Types	Federal ARARs
	RCRA
Ground water, Surface water, Landfill, Waste Pit/use restrictions	1) Use Restrictions (40 CFR 264.116)
	AIR
Ground water/ capping	1) Fugitive dust control from grading.
Surface water/ capping	2) To be considered is that regulations have been proposed and are being developed that would specifically require controls for landfills.
Soils in Waste Pit/ capping	
Soils and Waste in Landfill/capping	3) Another factor to be considered is the risks that arise through inhalation due to air emissions caused by a variety of remedial actions.
	RCRA
	1) Solid Waste Closure (Subtitle D) - Refer to Ohio solid waste regulations
	2) RCRA Landfill closure requirements - Closure requirements - 40 CFR 264.310 Post-closure care - 40 CFR 264.310(b) Use restrictions - 40 CFR 264.117 and 264.117(c)
Ground water/ monitoring	1) Substantive requirements of 40 CFR 264.92 -264.99
	AIR
Ground water/ collection/treatment	1) Air emissions may not exceed emission standards for this source established in the approved State SIP and any applicable New Source Performance Standards (NSPS) or National Emission Standards for Hazardous Air Pollutants (NESHAPs). Volatile organic compounds which may be emitted may require risk calculations.
Surface water/ collection/treatment/ disposal	

2) Special handling of spent activated carbon is required if radon products which may be present in the water lead to a concentration in the carbon that meets "radioactive" definition of DOT. Breakthrough or release of radon gas shall not create an occupational or public health threat and shall not exceed State radioactive emission standards. Radiation monitoring may be required in the design (and possibly throughout implementation) phase of the remedy.

RCRA

1) Groundwater concentration at the source of the cleanup program must be less than or equal to SDWA or RCRA MCL's at the point of compliance (waste unit boundary). Alternate Concentration Limits may only be used under the limited conditions outlined in CERCLA Section 121(d) (2) (B) (ii). Ambient Water Quality Criteria may also be ARARs under certain circumstances. A standard for drinking water more stringent than MCL's may be needed in special circumstances. In such cases the Agency will consider the MCLG and other pertinent guidelines. TBCs include Health Advisories and the 10^{-6} risk based levels established by the Endangerment Assessment for compounds without MCLs.

2) If collection/treatment activities require storage or treatment in tanks, or containers or miscellaneous RCRA units as defined in 260.10, then the Facility must comply with the substantive elements of 40 CFR 264. Also, if wastes are transported off-site, all applicable RCRA requirements for generators and transporters must be attained.

3) Disposal of any hazardous residuals must also take into consideration the CERCLA Off-site Policy.

Water

1) Discharge water from treatment unit must meet or exceed Clean Water Act NPDES permit discharge limits established for the particular discharge, depending on how and where discharge occurs. See State ARARs. TBCs include 10^{-6} risk levels established by the Endangerment Assessment for compounds without MCLs.

2) Standards, including the State's use designations and chemical limits, for prevention of chronically toxic conditions must be met at the point ground water infiltrates into surface water.

3) MCL's and AWQC, under the Safe Drinking Water Act and Clean Water Act, must be met for ground water at the completion of cleanup. A standard for drinking water more stringent than MCL's may be needed in certain instances. In such cases, the Agency will consider the MCLG and other pertinent guidelines.

4) 40 CFR 403 - General Pretreatment Regulations for Existing and New Sources of Pollution - Identifies treatment requirements for liquid waste streams before these streams can be discharged to a publicly owned treatment works (POTW).

RCRA

Surface water/ diversion culvert	1) RCRA landfill closure requirements- Closure requirements - 40 CFR 246.310.
	2) Solid waste closure - Refer to Ohio solid waste regulations.
Surface water/ batching	1) If activities require storage or treatment in tanks, or containers or miscellaneous RCRA units as defined in 260.10, then the facility must comply with the substantive elements of 40 CFR

264. Also, if wastes are transported off-site, all applicable RCRA requirements for generators and transporters will be attained for all waste transported off-site.

	Air
Soils in Waste Pit/ excavation and on-site treatment	1) Fugitive dust control from grading and excavation; vapor and other emissions during treatment of contaminated soils - requirements under the Clean Air Act.
	RCRA
	1) All requirements of 40 CFR 268 - Land Disposal Restrictions
	Air
Soils in Waste Pit/ excavation and incineration	1) Fugitive dust control from grading and excavation; vapor and other emissions during treatment - requirements under the Clean Air Act.
	2) State Implementation Plan requirements and applicable NSPS and NESHAPs limitations.
	3) TBCs include modeling to determine risk/limits of any emissions, volatiles, dioxins, etc.: particulate control - National Ambient Air Quality Standard for particles <10 micrometers (PM10) - 24- hr PM10 standard is 150 micrograms/cubic meter of air with no more that one exceedance/year, annual PM10 standard is $50 ug/m^3$ based on annual arithmetic mean; and temperature in secondary chamber maintained at minimum 2200F with minimum residence time of 1 second.
	RCRA
	1) Performance standards, including requirements for waste analysis, monitoring, inspections, and closure. See 40 CFR 264.340-264.351.

2) Achieve destruction and removal efficiency (DRE) of 99.99% for each principal organic hazardous constituent (POHC).

3) Trial burn and trial burn plan per 40 CFR Sections 270.62 and 270.19.

4) If incineration activities require storage or treatment in tanks, or containers or miscellaneous RCRA units as defined in 260.10, then the facility must comply with the substantive elements of 40 CFR 264.

<u>Water</u>

1) Any liquid hazardous waste streams resulting from incinerator will have to be dealt with in accordance with Federal and State Water ARARs described above.

<u>Air</u>

Soils in Waste Pit/ excavation and *in situ* vapor extraction	1) Point source emissions regulated by Clean Air Act.
	<u>Air and RCRA</u>
Soils in Waste Pit/Excavation and Off-site treatment	1) Excavation ARARs as above. 2) If wastes are transported off-site, the facility must comply with the generator substantive criteria of 40 CFR 262 and with the disposal requirements of CERCLA Section 121 (d)(3), and ensure transporter meets substantive requirements of 40 CFR 263. Off-site disposal must meet requirements of 40 CFR 268 (Land Disposal Restrictions).

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V

DATE:

DRAFT

SUBJECT: Water Division Review of the Request for ARARs for the Buckeye Reclamation Landfill Site in St. Clairsville Ohio

FROM: Charles H. Sutfin
Director, Water Division

TO: Basil G. Constantelos
Director, Waste Management Division

The Water Division has reviewed the subject document as requested by the Office of Superfund, and has the following comments.

Background

The site, located in Belmont County in eastern Ohio, and contains wastes associated with mining activities that occurred until about 1940. The site was licencensed as a sanitary landfill in 1971, and accepted municipal and industrial waste. The main threat to water quality at the site is from the mine wastes, which create acid mine drainage (AMD) and promote leaching of metals from the "gob pile". Municipal wastes were landfilled in this area and covered by gob and native clays, so AMD also leaches contaminants from the garbage.

This is an unglaciated area of Ohio that is dissected by valleys containing small streams. The gob pile and waste areas are in a valley below the crest of a ridge and in the drainage ravine for King's Run. Bedrock outcrops in the area of the ravine, displaying fairly horizontal structure. Ground water use is restricted to wells drilled in the Benwood Limeston and the Little McMahon Creek alluvial aquifer. The gob pile currently contributes to recharge of both water-bearing units.

Office of Ground Water

- It is the position of the Office of Ground Water that the RP's used the U.S. EPA Draft Ground Water Classification Guidelines (GWCGs) incorrectly. The GWCGs were intended to classify ground water to provide differential protection to naturally occurring ground water resources. The gob pile is not a naturally occurring water-bearing unit, is not below the land surface but rather rests on the natural surface, and represents more of a contaminant source than a ground water resource.

  However, the gob pile is in hydraulic connection to the alluvial aquifer along Little McMahon Creek, and the Benwood

Limestone at the site, which, by virtue of containing water wells, would be Class IIa ground waters (current drinking water source). Because the gob pile acts to recharge both aquifers, OGW believes the final selected remedy should include measures to minimize the hydraulic connection, including a full-site cap that at least meets Ohio solid waste disposal capping specifications. (T. Ballard, 3-1435)

Drinking Water Section

- CERCLA Section 121 requires selection of a Remedial Action that is protective of human health and the environment. The interim guidance to implement this requirement was published in the Federal Register, "Superfund Compliance With Applicable or Relevant and Appropriate Requirements" (52 FR 32498; August 27, 1987). In selecting protective standards for remediation of a contaminated water supply, the Safe Drinking Water Act (SDWA) serves to provide chemical-specific applicable or relevant and appropriate requirements (ARARs).

- The MCLs are the National Primary Drinking Water Regulations (NPDWR) promulgated at 40 CFR 141 pursuant to the SDWA. The MCLs are the enforceable drinking water standards and are applicable where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections. Hence, MCLs are applicable to public water systems and are relevant and appropriate to private water systems. When MCLs are applicable, they should at least be met at the tap. When MCLs are relevant and appropriate in other cases where surface water or ground water is or may be directly used for drinking water, and in such cases, the MCLs should be met in the surface water or ground water itself. The drinking water regulations are potential ARARS for this site since the Benwood Limestone and Little McMahon Creek aquifer are recharged by infiltration from the gob pile, and are used for drinking water.

- Where surface water is used for a drinking water supply, MCLs may still be potential ARARs; however, a zone of mixing may be allowed from the point of discharge. This is usually addressed in the National Pollutant Discharge Elimination System Permit process.

- Furthermore, while nonpromulgated guidance are not potential ARARs, they are still to-be-considered (TBC) as part of the site risk assessment and may be used in determining the necessary level of cleanup for protection of health or the environment. TBCs are non-promulgated advisories or guidance issued by Federal or State government that are not legally binding. However, TBCs may be considered along with ARARs. Examples of potential TBCs include health advisories, reference doses, potency factors, and secondary drinking water standards, and proposed primary and secondary drinking water treatment standards.

In assuring that the current drinking water standards are used, we have enclosed the most recent update of the Drinking Water Standards and Health Advisory Table for reference.

- Finally, as you know, adjustments may need to be made to these levels when ARARs and other selected criteria are outside the acceptable risk range. (S. Bianchin, 6-9537)

<u>Water Quality Permits</u>

- As a result of staffing constraints the Water Quality Branch was unable to review the subject document. No comments regarding surface water impacts or the regulatory requirements of the Clean Water Act potentially applicable to this site are being provided at this time.

Thank you for the opportunity to review this document. We would appreciate receiving feedback on the disposition of our major comments, as this will enhance our ability to provide useful input in the future. Marginal notations by the RPM on a copy of this memo would be sufficient, or a copy of any letter sent out to PRPs, contractor, etc. Should you, or the RPM, have any specific questions on a comment, please contact the appropriate reviewer.

cc: Don Bruce, 5HS-11
    Ken Tindall, 5HS-11

bcc: Garl
     Harrison
     Bianchin
     Henry

WTB:dc:Draft 1:6/27/89:Cercla II\final\buckeye.arr

Legend of Column Headings for Draft Version of
Drinking Water Standards and Health Advisories Table

Standards

NIPDWR - National Interim Primary Drinking Water Regulations: refers to the interim regulatory requirements under the Safe Drinking Water Act (SDWA) of 1974. The NIPDWR specified maximum allowable levels for 22 different contaminants at the consumer's drinking water tap. These interim standards, known as Maximum Contaminant Levels (MCL), were promulgated for 22 contaminants in March 1975, with the intention of revising and promulgating the final National Primary Drinking Water Regulations (NPDWR) a few years later. The values listed in this column are the original MCLs assigned under the interim regulations. The NPDWRs were effected under the SDWA Amendments of June 19, 1986. These revised regulations specify MCLs or treatment techniques for additional contaminants. At this time, 8 additional contaminants (synthetic volatile organic chemicals) have also been assigned MCLs. (Code of Federal Regulations, Chapter 40, part 141, et seq.)

MCLG - Maximum Contaminant Level Goal: Under the National Primary Drinking Water Regulations, the term MCLG now replaces the previous term RMCL or recommended Maximum Contaminant Level. Under the 1986 SDWA Amendments, any NPDWR which establishes an MCL must also simultaneously publish an MCLG at the time of proposed rulemaking and promulgation. The MCLG is the maximum level of a contaminant at which no known or anticipated adverse human health effects would occur, and which include an adequate margin of safety. MCLGs are nonenforceable health goals.

MCL - Maximum Contaminant Level: Derived from the MCLG, the MCL is the maximum permissible level of a contaminant in drinking water which is delivered to the consumers' tap and used by the general public for drinking. MCLs are legally enforceable. The standards reflect the best achievable levels considering the occurrence, relative source contribution factors, monitoring capability, cost of treatment, available technology and health effects. The standards listed in this column for each contaminant under the NIPDWR are either newly promulgated or revised from the NIPDWR. In a few cases, the enforceable standard has changed; however, in most cases (when comparing columns headed NIPDWR and MCL) the existing interim standard has been revised or has been newly developed.

Health Advisories

The Health Advisory (HA) program is sponsored by the Office of Drinking Water (ODW), and provides information on the health effects, analytical methods and treatment technology useful for dealing with drinking water contamination. Health advisories describe nonregulatory concentrations of drinking water contaminants at which adverse health effects would not be anticipated to occur over specific exposure durations. Health advisories contain a margin of safety, to protect sensitive members of the population. The Health Advisories are developed for one-day, ten-day, longer term and lifetime exposures based on data describing non carcinogenic endpoints of toxicity. The advisories are intended to serve as informal technical guidance to assist Federal, State and local officials when emergency spills or contaminant situations occur. They are not construed as legally enforceable Federal standards and are subject to change as new information becomes available.

10-Kg Child, 1-Day, 10-Day and Longer Term

The child is assumed to be a more sensitive population entity. Included in this assumption, is that the body weight of a child is 10 kg and that one liter of water per day is ingested. Under these and other assumptions specific to the available toxicological data base, Health Advisory values have been derived and listed in the respective columns for one-day, ten-day and longer term exposures. Longer term is defined as approximately 7 years, or 10 percent of an individual's lifetime.

70-Kg Adult

Health Advisory values for the adult are derived in the same way as for the 10-kg child. Again, certain assumptions are made: The adult is assumed to weigh 70 kg and consume 2 liters of water per day.

Longer Term: As with the 10-kg child, longer term exposure is approximately 7 years or 10 percent of an individual's lifetime.

RfD - Reference Dose: formerly known as the Acceptable Daily Intake (ADI), the RfD is an estimate of a daily exposure to the human population (including sensitive subpopulations) that is likely to be without appreciable risk or deleterious effects over a lifetime. The RfD is expressed in units of daily dose.

DWEL - Drinking Water Equivalent Lifetime: The medium-specific (i.e., drinking water) lifetime exposure level, assuming 100 percent exposure from that medium, at which adverse noncarcinogenic health effects would not be expected to occur. The DWEL is derived from multiplying the RfD by the adult body weight (70kg) and divided by the adult daily water consumption (2 liters/day).

Lifetime Health Advisory: This value is determined by factoring in other sources of exposure to the particular contaminant. The relative source contribution from drinking water is based on actual exposure data. If data are unavailable, a value of 20 percent is assumed for synthetic organic chemical contaminants and a value of 10 percent assumed for inorganic chemical contaminants. The lifetime Health Advisory is determined by multiplying the DWEL by the relative source contribution from drinking water.

Dw/l at 10^{-4} Cancer Risk: This column contains values indicating the concentration of the particular contaminant in drinking water that would produce a 10^{-4} excess lifetime cancer risk. Simply stated, if a group of 10,000 persons was exposed to the contaminant at its respective concentration listed in this column, then one individual in the group might be expected to develop cancer (above background incidence) solely from exposure to that contaminant in drinking water.

Cancer Group: The Office of Health and Environmental Assessment (OHEA) within EPA's Office of Research and Development (ORD) has developed guidelines for carcinogen risk assessment. These guidelines discuss weighing the evidence that a substance is a carcinogen, and classifying the chemical into one of five groups, based on the weight of evidence:

Group A - Human carcinogen
Group B - Probable human carcinogen
Group B consists of two sub-classifications:
B_1 - limited human evidence but sufficient animal evidence
B_2 - Sufficient animal evidence, but inadequate or no human evidence
Group C - Possible human carcinogen
Group D - Not classified as to human carcinogenicity
Group E - Evidence of noncarcinogenicity for humans

(*) The codes for the Status Reg and Status HA columns are as follows:

F - final
D - draft
L - listed for regulation
P - proposed (Phase II draft proposal, based on levels proposed in 1985)

Other codes found in the table include the following:

NA - not applicable
PS - performance standard 0.5 NTU - 1.0 NTU
TT - treatment technique
** - no more than 5% of the samples may be positive. For systems collecting fewer than 40 samples/month, no more than 1% may be positive.
*** - guidance
† - large discrepancies between Lifetime and Longer term HA values may occur because of the Agency's conservative policies, especially with regard to carcinogenicity, relative source contribution, and less than lifetime exposures in chronic toxicity testing. These factors can result in a cumulative UF (uncertainty factor) of 10 to 1,000 when calculating a Lifetime HA.

DRINKING WATER STANDARDS AND HEALTH ADVISORIES

Chemicals	Standards: Status Reg.*	Standards: NPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One-day µg/l	10 kg Child: Ten-day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
ORGANICS														
Acenaphthylene	-	-	-	-	-	-	-	-	-	60	-	-	-	-
Acifluorfen	-	-	-	-	F	2000	2000	100	400	13	400	-	100	B2
Acrylamide	P	-	zero	TT	F	1500	300	20	70	0.2	7	-	1	B2
Acrylonitrile	L	-	-	-	B	20	20	1	4	0.1	4	-	7	B1
Adipates (diethylhexyl)	T	-	500	500	-	-	-	-	-	700	20000	500	-	C
Alachlor	P	-	zero	2	F	100	100	-	-	10	400	-	40	B2
Aldicarb	P	-	10	10	F	10	10	10	10	1.3	40	10	-	D
Aldicarb sulfone	P	-	40	40	F	60	60	60	200	6.0	200	40	-	D
Aldicarb sulfoxide	P	-	10	10	F	10	10	10	40	1.3	40	10	-	D
Aldrin	-	-	-	-	B	0.3	0.3	0.3	0.9	0.03	0.9	-	0.2	B2
Ametryn	-	-	-	-	F	9000	9000	900	3000	9	300	60	-	D
Ammonium Sulfamate	-	-	-	-	F	20000	20000	20000	80000	250	8000	2000	-	D
Anthracene (PAH)	L	-	-	-	-	-	-	-	-	300	-	-	-	D
Atrazine	P	-	3	3	F	100	100	50	200	5	200	3	-	C
Baygon	-	-	-	-	F	40	40	40	100	4	100	3	-	C
Bentazon	-	-	-	-	F	300	300	300	900	2.5	90	20	-	D
Benz(a)anthracene (PAH)	T	-	zero	0.1	-	-	-	-	-	-	-	-	-	B2
Benzene	F	-	zero	5	F	200	200	-	-	-	-	-	100	A
Benzo(a)pyrene (PAH)	T	-	zero	0.2	-	-	-	-	-	-	-	-	-	B2*
Benzo(b)fluoranthene (PAH)	T	-	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Benzo(g,h,i)perylene (PAH)	T	-	-	-	-	-	-	-	-	-	-	-	-	D
Benzo(k)fluoranthene (PAH)	T	-	zero	0.2	-	-	-	-	-	-	-	-	-	B2
bis-2-Chloroisopropyl ether	-	-	-	-	F	4000	4000	4000	13000	40	1000	300	-	-
Bromacil	-	-	-	-	F	5000	5000	3000	9000	130	5000	90	-	C
Bromobenzene	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Bromochloroacetonitrile	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Bromochloromethane	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Bromodichloromethane (THM)	L	100	-	-	D	7000	7000	100	700	20	700	-	30	B2
Bromoform (THM)	L	100	-	-	D	15000	15000	100	700	20	700	-	-	B2
Bromomethane	-	-	-	-	F	100	100	100	500	1	50	10	-	D

Chemicals	Standards: Status Reg.*	Standards: NPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One-day µg/l	10 kg Child: Ten-day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Butyl benzyl phthalate (BBP)	T	-	-	-	-	-	-	-	-	200	-	-	-	C
Butylate	-	-	-	-	F	2000	2000	1000	4000	50	2000	350	-	D
Butylbenzene n-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Butylbenzene sec-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Butylbenzene tert-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Carbaryl	-	-	-	-	F	1000	1000	1000	1000	100	4000	700	-	D
Carbofuran	P	-	40	40	F	50	50	50	200	5	200	40	-	E
Carbon Tetrachloride	F	-	zero	5	F	4000	200	70	300	0.7	30	-	30	B2
Carboxin	-	-	-	-	F	1000	1000	1000	4000	100	4000	700	-	D
Chloral Hydrate	L	-	-	-	D	7000	1000	200	600	2	60	50	-	D
Chloramben	-	-	-	-	F	3000	3000	200	500	15	500	100	-	D
Chloramine	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlorate	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlordane	P	-	zero	2	F	60	60	0.5	0.5	0.045	2	-	3	B2
Chlorine	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlorine dioxide	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlorite	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlorodibromomethane (THM)	L	100	-	-	D	7000	7000	100	700	20	700	100	-	C
Chloroethane	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chloroform (THM)	L	100	-	-	D	-	-	-	-	10	-	-	600	B2
Chloromethane	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Chlorophenol (2,4,6-)	L	-	-	-	D	-	-	-	-	-	-	-	300	B2
Chlorophenol (2,4-)	L	-	-	-	D	30	30	30	100	3	100	20	-	D
Chlorophenol (2-)	L	-	-	-	D	50	50	50	200	5	200	40	-	D
p Chlorophenyl methyl sulfide/sulfone/sulfoxide	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chloropicrin	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorothalonil	-	-	-	-	F	200	200	200	-	15	600	-	150	B2
Chlorotoluene o-	L	-	-	-	F	2000	2000	2000	7000	20	700	100	-	D
Chlorotoluene p-	L	-	-	-	F	2000	2000	2000	7000	20	700	100	-	D
Chlorpyrifos	-	-	-	-	D	30	30	30	100	3	100	20	-	D

Chemicals	Standards: Status Reg.*	NPDWR (μg/l)	MCLG (μg/l)	MCL (μg/l)	Health Advisories: Status HA*	10 kg Child: One day μg/l	Ten day μg/l	Longer-term μg/l	70 kg Adult: Longer-term μg/l	RfD μg/kg/day	DWEL μg/l	Lifetime μg/l	μg/l at 10^{-4} Cancer Risk	Cancer Group
Chrysene (PAH)	-	-	zero	0.2	-	-	-	-	-	-	-	-	-	B2
Cyanazine	L	-	-	-	F	100	100	20	70	2	70	10	-	D
Cyanogen Chloride	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Cymene p-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
2,4 D	P	100	70	70	F	1000	300	100	400	10	400	70	-	D
DCPA (Dacthal)	-	-	-	-	F	80000	80000	5000	20000	500	20000	4000	-	D
Dalapon	T	-	200	200	F	3000	3000	300	900	26	900	200	-	D
Dichloroethylene (cis-1,2-)	P	-	70	70	F	4000	1000	3500	1000	10	400	70	-	D
Dichloroethylene (trans-1,2)	P	-	100	100	F	20000	2000	2000	6000	20	600	100	-	D
Diazinon	-	-	-	-	F	20	20	5	20	0.09	3	0.6	-	E
Dibenz(a,h)anthracene (PAH)	T	-	zero	0.3	-	-	-	-	-	-	-	-	-	B2
Dibromoacetonitrile	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Dibromochloropropane (DBCP)	P	-	zero	0.2	F	200	50	-	-	-	-	-	3	B2
Dibromomethane	L	-	-	-	D	-	-	-	-	-	-	-	-	D
Dibutyl phthalate (DBP)	T	-	-	-	-	-	-	-	-	100	-	-	-	D
Dicamba	L	-	-	-	F	300	300	300	1000	30	1000	200	-	D
Dichloroacetaldehyde	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroacetic acid	L	-	-	-	D	50000	50000	500	2000	5	200	3	-	C
Dichloroacetonitrile	L	-	-	-	D	-	-	-	-	8	-	-	-	C
Dichlorobenzene p-	F	-	75	75	F	10000	10000	10000	40000	100	4000	75	-	C
Dichlorobenzene o-,m-	P	-	600	600	F	9000	9000	9000	30000	89	3000	600	-	D
Dichlorodifluoromethane	-	-	-	-	F	40000	40000	9000	30000	200	5000	1000	-	D
Dichloroethane (1,1-)	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloroethane (1,2)	F	-	zero	5	F	700	700	700	2600	-	-	-	40	B2
Dichloroethylene (1,1-)	F	-	7	7	F	2000	1000	1000	4000	9	400	7	0.02	C
Dichloromethane	T	-	zero	5	F	10000	2000	-	-	60	2000	-	500	B2
Dichloropropane (1,1-)	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (1,2)	P	-	zero	5	F	-	90	-	-	-	-	-	60	B2
Dichloropropane (1,3)	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropane (2,2)	L	-	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	Standards: NIPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One-day µg/l	10 kg Child: Ten-day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Dichloropropene (1,1)	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Dichloropropene (1,3)	L	-	-	-	F	30	30	30	100	0.3	10	-	20	B2
Dieldrin	L	-	-	-	F	0.5	0.5	0.5	2	0.05	2	-	0.2	B2
Diethyl phthalate (DEP)	T	-	-	-	D	-	-	-	-	800	-	-	-	D
Diethylhexyl phthalate (DEHP)	T	-	zero	4	D	-	-	-	-	20	-	-	300	B2*
Diisopropyl methylphosphonate	-	-	-	-	F	8000	8000	8000	30000	80	3000	600	-	D
Dimethrin	-	-	-	-	F	10000	10000	10000	40000	300	10000	2000	-	D
Dimethyl methylphosphonate	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Dimethyl phthalate (DMP)	L	-	-	-	-	-	-	-	-	-	-	-	-	D
1,3 Dinitrobenzene	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Dinitrotoluene (2,4)	L	-	-	-	D	-	-	-	-	-	-	-	-	-
2,4-/2,6 Dinitrotoluene	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Dinoseb	T	-	7	7	I	300	300	10	40	1	40	7	-	D
Dioxane p-	-	-	-	-	F	4000	400	-	-	-	-	-	700	B2
Diphenamid	-	-	-	-	F	300	300	300	1000	30	1000	200	-	D
Diquat	T	-	20	20	-	-	-	-	-	2.2	-	-	-	D
Disulfoton	-	-	-	-	F	10	10	3	9	0.04	1	0.3	-	E
1,4 Dithiane	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diuron	-	-	-	-	F	1000	1000	300	900	2	70	10	-	D
Endothall	T	-	100	100	F	800	800	200	200	20	700	100	-	D
Endrin	T	0.2	2	2	F	20	20	3	10	3	9	2	-	D
Epichlorohydrin	P	-	zero	TT	F	100	100	70	70	2	70	-	400	B2
Ethylbenzene	P	-	700	700	F	30000	3000	1000	3000	100	3000	700	-	D
Ethylene dibromide (EDB)	P	-	zero	0.05	F	8	8	-	-	-	-	-	0.04	B2
Ethylene glycol	-	-	-	-	F	20000	6000	6000	20000	2000	40000	7000	-	D
ETU	L	-	-	-	F	300	300	100	400	0.03	1	-	20	B2
Fenamiphos	-	-	-	-	F	9	9	5	20	0.25	9	2	-	D
Fluometuron	-	-	-	-	F	2000	2000	2000	5000	13	400	90	-	D
Fluorene (PAH)	T	-	-	-	-	-	-	-	-	40	-	-	-	D
Fluorotrichloromethane	-	-	-	-	F	7000	7000	3000	12000	300	10000	2000	-	D

	Standards				Health Advisories									
					10 kg Child			70 kg Adult						
Chemicals	Status Reg.*	NPDWR (μg/l)	MCLG (μg/l)	MCL (μg/l)	Status HA*	One day μg/l	Ten day μg/l	Longer-term μg/l	Longer-term μg/l	RfD μg/kg/day	DWEL μg/l	Lifetime μg/l	μg/l at 10^{-4} Cancer Risk	Cancer Group
Fog Oil	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Fonofos	-	-	-	-	F	20	20	20	70	2	70	10	-	D
Formaldehyde	-	-	-	-	D	10000	5000	5000	20000	150	5000	1000	-	B1-inhal
Gasoline	-	-	-	-	D	-	-	-	-	-	-	5(benzene)	-	-
Glyphosate	T	-	700	700	F	20000	20000	1000	1000	100	4000	700	-	D
Heptachlor	P	-	zero	0.4	F	10	10	5	5	0.5	20	-	0.8	B2
Heptachlor epoxide	P	-	zero	0.2	F	10	-	0.1	0.1	0.013	0.4	-	0.4	B2
Hexachlorobenzene	T	-	zero	1	F	50	50	50	200	0.8	30	-	2	B2
Hexachlorobutadiene	-	-	-	-	F	300	300	100	400	2	70	1	60	C
Hexachlorocyclopentadiene	T	-	50	50	-	-	-	-	-	7	200	-	-	D
Hexane (n)	-	-	-	-	F	10000	4000	4000	10000	-	-	-	-	D
Hexazinone	-	-	-	-	F	3000	3000	3000	9000	30	1000	200	-	D
HMX	-	-	-	-	F	5000	5000	5000	20000	50	2000	400	-	D
Hypochlorite	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Hypochlorous acid	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3,-c,d)pyrene (PAH)	T	-	zero	0.4	D	-	-	-	-	-	-	-	-	B2
Isophorone	L	-	-	-	D	15000	15000	15000	15000	200	7000	100	900	C
Isopropyl methylphosphonate	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Lindane	P	4	0.2	0.2	F	1000	1000	30	100	0.3	10	0.2	3	C
Malathion	-	-	-	-	D	200	200	200	800	20	800	200	-	D
Maleic hydrazide	-	-	-	-	F	10000	10000	5000	20000	500	20000	4000	-	D
MCPA	-	-	-	-	F	100	100	100	400	1.5	53	11	-	E
Methomyl	-	-	-	-	F	300	300	300	300	25	800	200	-	D
Methoxychlor	P	100	400	400	F	6000	2000	500	2000	50	2000	400	-	D
Methyl ethyl ketone	-	-	-	-	F	80000	8000	3000	9000	25	900	200	-	D
Methyl parathion	-	-	-	-	F	300	300	30	100	0.25	9	2	-	D
Methyl tert butyl ether	L	-	-	-	D	3000	3000	500	2000	5	200	40	-	D
Metolachlor	L	-	-	-	F	2000	2000	2000	5000	150	5000	100	-	C
Metribuzin	L	-	-	-	F	5000	5000	300	900	25	900	200	-	D

Chemicals	Standards: Status Reg.*	Standards: NIPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One day µg/l	10 kg Child: Ten day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	70 kg Adult: µg/l at 10^{-4} Cancer Risk	Cancer Group
Monochloroacetic acid	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Monochlorobenzene	P	-	100	100	F	2000	2000	2000	7000	20	700	100	-	D
Naphthalene	-	-	-	-	D	500	500	500	2000	40	1000	300	-	D
Nitrocellulose (non toxic)	-	-	-	-	F	-	-	-	-	-	-	-	-	-
Nitroguanidine	-	-	-	-	D	10000	10000	10000	40000	100	4000	700	-	D
Oxamyl (Vydate)	T	-	200	200	F	200	200	200	900	25	900	200	-	E
Ozone by-products	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Paraquat	-	-	-	-	F	100	100	50	200	4.5	200	30	-	E
Pentachloroethane	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Pentachlorophenol	P	-	0/2000	1/200	F	1000	300	300	1000	30	1000	0/200	-	B2/D
Phenanthrene (PAH)	T	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenol	-	-	-	-	D	6000	6000	6000	20000	600	20000	4000	-	D
Picloram	T	-	500	500	F	20000	20000	700	2000	70	2000	500	-	D
Polychlorinated byphenols (PCBs)	P	-	zero	0.5	P	-	-	1	4	-	-	-	0.5	B2
Prometon	-	-	-	-	F	200	200	200	500	15	500	100	-	D
Pronamide	-	-	-	-	F	800	800	800	3000	75	3000	60	-	C
Propachlor	-	-	-	-	F	500	500	100	500	13	500	90	-	D
Propazine	-	-	-	-	F	1000	1000	500	2000	20	700	10	-	C
Propham	-	-	-	-	F	5000	5000	5000	20000	20	600	100	-	D
Propylbenzene n-	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Pyrene (PAH)	T	-	-	-	-	-	-	-	-	30	-	-	-	D
RDX	-	-	-	-	F	100	100	100	400	3	100	2	30	C
Simazine	T	-	1	1	F	500	500	50	200	2	60	1	-	C
Styrene	P	-	zero/100	5/100	F	20000	2000	2000	7000	200	7000	0/100	1	B2/C
2,4,5-T	L	-	-	-	F	800	800	800	1000	10	350	70	-	D
2,3,7,8-TCDD (Dioxin)	T	-	zero	$5x10^{-8}$ mg/l	F	0.001E-04		1E-05	4E-05	1E-08	4E-05	-	2E-05	B2
Tebuthiuron	-	-	-	-	F	3000	3000	700	2000	70	2000	500	-	D
Terbacil	-	-	-	-	F	300	300	300	900	13	400	90	-	E
Terbufos	-	-	-	-	F	5	5	1	5	0.13	5	0.9	-	D
Tetrachloroethane (1,1,1,2)	L	-	-	-	F	2000	2000	900	3000	30	1000	70	100	C

Chemicals	Standards: Status Reg.*	Standards: NPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One day µg/l	10 kg Child: Ten day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Tetrachloroethane (1,1,2,2)	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	P	-	zero	5	F	2000	2000	1000	5000	10	500	-	70	B2
Toluene	P	-	2000	2000	F	20000	3000	3000	10000	300	10000	2000	-	D
Toxaphene	P	5	zero	5	F	500	40	-	-	100	3.5	-	3	B2
2,4,5-TP	P	10	50	50	F	200	200	70	300	7.5	300	50	-	D
1,1,2-Trichloro-1,2,2-trifluoroethane	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroacetic acid	L	-	-	-	D	30000	30000	30000	100000	300	10000	200	-	C
Trichloroacetonitrile	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Trichlorobenzene (1,2,4)	T	-	9	9	F	100	100	100	500	1	50	9	-	D
Trichlorobenzene (1,3,5)	-	-	-	-	F	600	600	600	2000	6	200	40	-	D
Trichloroethane (1,1,1)	F	-	200	200	F	100000	40000	40000	100000	90	1000	200	-	D
Trichloroethane (1,1,2)	T	-	3	5	F	600	400	400	1000	4	100	3	60	C
Trichloroethanol (2,2,2)	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	F	-	zero	5	F	-	-	-	-	7	300	-	300	B2
Trichloropropane (1,1,1)	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Trichloropropane (1,2,3)	-	-	-	-	F	600	600	600	2000	6	200	40	-	-
Trifluralin	L	-	-	-	F	30	30	30	100	7.5	260	5	500	C
Trimethylbenzene (1,2,4)	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Trimethylbenzene (1,3,5)	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Trinitroglycerol	-	-	-	-	F	5	5	5	5	-	-	5	-	-
Trinitrotoluene	-	-	-	-	F	20	20	20	20	0.5	20	2	100	C
Vinyl chloride	F	-	zero	2	F	3000	3000	10	50	-	-	-	1.5	A
White phosphorus	-	-	-	-	D	-	-	-	-	-	-	-	-	-
Xylenes	P	-	10000	10000	F	40000	40000	40000	100000	2000	60000	10000	-	D
Zinc chloride	-	-	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	Standards: NIPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One day µg/l	10 kg Child: Ten day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	70 kg Adult: µg/l at 10^{-4} Cancer Risk	Cancer Group
INORGANICS														
Aluminum	L	-	-	-	D	-	-	-	-	-	-	-	-	-
Ammonia	L	-	-	-	D	-	-	-	-	-	-	30000	-	D
Antimony	T	-	3	10/5	D	15	15	15	15	0.4	15	3	-	D
Arsenic	T	50	zero	-	D	-	-	-	-	1	-	-	3	A
Asbestos (fibers/l > 10µm)	P	-	7E+06	7E+06	-	-	-	-	-	-	-	-	-	-
Barium	P	1000	5000	5000	F	5000	5000	5000	5000	-	-	5000	-	D
Beryllium	T	-	zero	1	D	30000	30000	4000	20000	5	200	-	0.7	B2
Boron	L	-	-	-	D	2000	2000	900	3000	90	3000	600	-	D
Cadmium	P	10	5	5	F	40	40	5	20	0.5	20	5	-	D
Chromium (total)	P	50	100	100	F	1000	1000	200	800	5	200	100	-	D
Copper	P	-	1300	1300	-	-	-	-	-	-	-	-	-	D
Cyanide	T	-	200	200	F	200	200	200	800	22	800	200	-	D
Fluoride	F	$f^{1,4}$ 2.4	4000	4000	-	-	-	-	-	60	-	-	-	-
Lead (at source)	P	-	zero	5	-	-	-	-	-	-	-	-	-	B2
Lead (at tap)	P	50	zero	TT	-	-	-	-	-	-	-	-	-	B2
Manganese	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury	P	2	2	2	F	-	-	-	2	0.3	10	2	-	D
Molybdenum	L	-	-	-	D	-	-	-	-	-	-	-	-	D
Nickel	T	-	100	100	F	1000	1000	100	600	20	600	100	-	D
Nitrate (as N)	P	10000	10000	10000	F	-	10000	-	-	-	-	-	-	D
Nitrite (as N)	P	-	1000	1000	F	-	1000	-	-	-	-	-	-	D
Nitrate + Nitrite	P	-	10000	10000	-	-	-	-	-	-	-	-	-	-
Selenium	P	10	50	50	-	-	-	-	-	-	-	-	-	-
Silver	L	50	-	-	D	200	200	200	200	5	200	100	-	D
Sodium	L	-	-	-	D	-	-	-	-	-	20000***	-	-	-
Strontium	L	-	-	-	D	25000	25000	25000	90000	2500	90000	17000	-	D
Sulfate	T	-	400000	400000	-	-	-	-	-	-	-	-	-	-
Thallium	T	-	0.5	2/1	D	7	7	7	20	0.07	2	0.4	-	-
Vanadium	L	-	-	-	D	-	-	-	-	-	-	-	-	D
Zinc	L	-	-	-	D	-	-	-	-	-	-	-	-	-

Chemicals	Standards: Status Reg.*	Standards: NPDWR (µg/l)	Standards: MCLG (µg/l)	Standards: MCL (µg/l)	Health Advisories: Status HA*	10 kg Child: One day µg/l	10 kg Child: Ten day µg/l	10 kg Child: Longer-term µg/l	70 kg Adult: Longer-term µg/l	70 kg Adult: RfD µg/kg/day	70 kg Adult: DWEL µg/l	70 kg Adult: Lifetime µg/l	70 kg Adult: µg/l at 10^{-4} Cancer Risk	Cancer Group
MICROBIOLOGY AND TURBIDITY														
Cryptosporidium	L	-	-	-	-	-	-	-	-	-	-	-	-	-
Giardia lamblia	F	-	zero	TT	-	-	-	-	-	-	-	-	-	-
Legionella	F	-	zero	TT	F	-	-	-	-	-	-	-	-	-
Standard plate count	F	-	NA	TT	-	-	-	-	-	-	-	-	-	-
Total coliform (current MCL based on density)	F	yes	NA	varies	-	-	-	-	-	-	-	-	-	-
Total coliform (after 12/31/90)	F	yes	zero	**	-	-	-	-	-	-	-	-	-	-
Turbidity (before 1/1/91)	F	yes	NA	-	-	-	-	-	-	-	-	-	-	-
Turbidity (after 12/31/90)	F	yes	NA	1 & 5 NTU/PS	-	-	-	-	-	-	-	-	-	-
Viruses	F	-	zero	TT	-	-	-	-	-	-	-	-	-	-

Key: PS, TT, F, defined as previously stated.

: Final for systems using surface water; also being considered for regulation under groundwater disinfection rule.

Varies: MCL varies based on analytical method used, sample volume, and number of samples collected per month. Also, two types of MCLs – the monthly average and the "single sample" MCL. Both are based on coliform density.

1 and 5 NTU: These are two MCLs for turbidity. The monthly average MCL is 1 NTU; the two-day consecutive average MCL is 5 NTU.

RADIONUCLIDES

Chemicals	Status Reg.*	NPDWR (µg/l)	MCLG (µg/l)	MCL (µg/l)	Status HA*	One day µg/l	Ten day µg/l	Longer-term µg/l	Longer-term µg/l	RfD µg/kg/day	DWEL µg/l	Lifetime µg/l	µg/l at 10^{-4} Cancer Risk	Cancer Group
Beta particle and photon activity (formerly man-made radionuclides)	T	mrem/yr	zero	-	-	-	-	-	-	-	-	-	4 mrem/y	A
Gross alpha particle activity	T	15 pCi/l	zero	-	-	-	-	-	-	-	-	-	-	A
Radium 226/228	T	5 pCi/l	zero	-	-	-	-	-	-	-	-	-	20 pCi/l	A
Radon	T	-	zero	-	-	-	-	-	-	-	-	-	150 pCi/l	A
Uranium	T	-	zero	-	-	-	-	-	-	-	-	-	160 pCi/l	A

MICROBIOLOGY

	Status	NIPDWR	MCLG	MCL
Cryptosporidium	L	-	-	-
Giardia lamblia	F	-	zero	TT
Legionella	F[a]	-	zero	TT
Standard Plate Count	F[a]	-	NA	TT
Total Coliforms (Current)	F	yes	NA	varies
Total Coliforms (after 12/31/90)	F	-	zero	**
Turbidity (before 1/1/91)	F	yes	NA	1 and 5 NTU
Turbidity (after 12/31/90)	F	-	NA	PS
Viruses	F[a]	-	zero	TT

SECONDARY MAXIMUM CONTAMINANT LEVELS

Chemicals	Status*	SMCLs (mg/l)
Aluminum	P	0.05 to 0.2
Chloride	F	250
Color	F	15 color units
Copper	F	1
Corrosivity	F	non-corrosive
Dichlorobenzene -o	P	0.01
Dichlorobenzene -p	P	0.005
Ethylbenzene	P	0.03
Fluoride	F	2
Foaming Agents	F	0.5
Hexachlorocyclopentadiene		0.008
Iron	F	0.3
Manganese	F	0.05
Odor	F	3 threshold odor numbers
Pentachlorophenol	P	0.03
pH	F	6.5 - 8.5
Silver	P	0.09
Sulfate	F	250
Toluene	P	0.04
Total Dissolved Solids (TD)	F	500
Xylene	P	0.02
Zinc	F	5

* Status Codes: P - proposed, F - final

REGULATIONS

OAC 3701-28	Rules providing standards, procedures, plan approval, abandonment of private water systems.
OAC 3745-1-05(A)	Antidegradation policy for surface water.
OAC 3745-1-05(B)	The most stringent statutory and regulatory controls for waste treatment shall be required by the Director to be employed for all new and existing point sources.
OAC 3745-3-04	Prohibited discharges to a POTW.
OAC 3745-3	Chapter establishes pre-treatment standards, restrictions, reporting, etc., for dishcarges to a POTW.
OAC 3745-15-07	Prohibition of air pollution nuisance, re: escape of smoke, ashes, dust, dirt, grime, acids, fumes, gasses, vapors, odors, or any other substances or combinations of substances.
OAC 3745-15-06	Malfunction of equipment, scheduled maintenance, reporting.
OAC 3745-17-05	Non-degradation policy - prohibits significant and avoidable deterioration of air quality.
OAC 3745-17-07	Control of visible particulate emissions from stationary sources. No discharges allowed over 20% opacity.
OAC 3745-17-08	Restriction of emission of fugitive dust.
OAC 3745-17-09	Restrictions on particulate emissions from incinerators.
OAC 3745-17-10	Restrictions on particulate emissions from fuel burning equipment.
OAC 3745-17-11	Restriction on particulate emissions from industrial processes.

ADDENDUM TO OHIO ADMINISTRATIVE CODE (OAC) ARARS - SOLID WASTE REGULATIONS FOR BUCKEYE RECLAMATION LANDFILL

OAC CITATION	PERTINENT PARAGRAPHS	TITLE / SUBJECT OF REGULATION	DESCRIPTION OF REGULATION	APPLICATION OF REGULATION	ARAR TYPE
			AND SURFACE WATER MANAGEMENT.	IN-PLACE PER SOLID WASTE RULES.	
3745-27-10	B,C,D	SANITARY LANDFILL - GROUND WATER MONITORING	GROUND WATER MONITORING PROGRAM MUST BE ESTABLISHED FOR ALL SANITARY LANDFILL FACILITIES. THE SYSTEM MUST CONSIST OF A SUFFICIENT NUMBER OF WELLS THAT ARE LOCATED SO THAT SAMPLES INDICATE BOTH UPGRADIENT (BACKGROUND) AND DOWNGRADIENT WATER SAMPLES. THE SYSTEM MUST BE DESIGNED PER THE MINIMUM REQUIREMENTS SPECIFIED IN THIS RULE. THE SAMPLING AND ANALYSIS PROCEDURES MUST COMPLY WITH THIS RULE	PERTAINS TO ANY NEW SOLID WASTE FACILITY AND ANY EXPANSIONS OF EXISTING SOLID WASTE LANDFILLS ON-SITE. PORTIONS ALSO PERTAIN TO EXISTING AREAS OF CONTAMINATION THAT ARE CAPPED IN-PLACE PER THE SOLID WASTE RULES.	ACTION
3745-27-11	B,E	FINAL CLOSURE OF SANITARY LANDFILL FACILITIES	SPECIFIES THE MINIMUM INFORMATION NECESSARY FOR OHIO EPA TO DETERMINE ADEQUACY OF CLOSURE METHODS FOR SOLID WASTE LANDFILLS SPECIFIES ACCEPTABLE CAP DESIGN; SOIL BARRIER LAYER, GRANULAR DRAINAGE LAYER, SOIL AND VEGETATIVE LAYER.	SUBSTANTIVE REQUIREMENTS PERTAIN TO ANY NEW SOLID WASTE LANDFILLS CREATED ON-SITE, ANY EXPANSIONS OF EXISTING SOLID WASTE LANDFILLS ON-SITE AND ANY EXISTING AREAS OF CONTAMINATION THAT ARE CAPPED IN-PLACE PER THE SOLID WASTE RULES.	ACTION
3745-27-12	B,E	SANITARY LANDFILL - EXPLOSIVE GAS MONITORING	ESTABLISHES WHEN AN EXPLOSIVE GAS MONITORING PLAN IS REQUIRED FOR SOLID WASTE LANDFILLS. SPECIFIES THE MINIMUM INFORMATION REQUIRED IN SUCH A PLAN, INCLUDING DETAILED ENGINEERING PLANS, SPECIFICATIONS, INFORMATION ON GAS GENERATION POTENTIAL, SAMPLING AND MONITORING PROCEDURES, ETC. MANDATES WHEN REPAIRS MUST BE MADE TO AN EXPLOSIVE GAS MONITORING SYSTEM. THIS RULE ONLY APPLIES TO LANDFILLS WHICH RECEIVE "PUTRESCIBLE" SOLID WASTES.	PERTAINS TO ANY SITE WHICH HAS HAD OR WILL HAVE PUTRESCIBLE SOLID WASTES PLACED ON-SITE AND WHICH HAS A RESIDENCE OR OTHER OCCUPIED STRUCTURE LOCATED WITHIN 1000 FEET OF THE EMPLACED SOLID WASTE.	ACTION
3745-27-13	A,F-G,[illegible]	NOTE TO "SITE" WHERE HAZ OR SOLID WASTE FAC HAS OPERATED	PROHIBITS ANY FILLING, GRADING, EXCAVATING, BUILDING, DRILLING OR MINING ON LAND WHERE A HAZARDOUS WASTE FACILITY OR SOLID	SUBSTANTIVE REQUIREMENTS PERTAIN TO ANY SITE AT WHICH HAZARDOUS OR SOLID WASTE HAS BEEN MANAGED, EITHER INTENTIONALLY OR	LOCATION ACTION

ADDENDUM TO OHIO ADMINISTRATIVE CODE (OAC) ARARS - SOLID WASTE REGULATIONS FOR BUCKEYE RECLAMATION LANDFILL

OAC CITATION	PERTINENT PARAGRAPHS	TITLE / SUBJECT OF REGULATION	DESCRIPTION OF REGULATION	APPLICATION OF REGULATION	ARAR TYPE
			WASTE FACILITY WAS OPERATED WITHOUT PRIOR AUTHORIZATION FROM THE DIRECTOR. SPECIAL TERMS TO CONDUCT SUCH ACTIVITIES MAY BE IMPOSED BY THE DIRECTOR TO PROTECT THE PUBLIC AND THE ENVIRONMENT.	OTHERWISE. DOES NOT PERTAIN TO AREAS THAT HAVE NO ONE-TIME LEAKS OR SPILLS.	
3745-27-14	A	POST-CLOSURE CARE OF SANITARY LANDFILL FACILITIES	SPECIFIES THE REQUIRED POST-CLOSURE CARE FOR SOLID WASTE FACILITIES. INCLUDES CONTINUING OPERATION OF LEACHATE AND SURFACE WATER MANAGEMENT SYSTEMS, MAINTENANCE OF THE CAP SYSTEM AND GROUND WATER MONITORING.	SUBSTANTIVE REQUIREMENTS PERTAIN TO ANY NEWLY CREATED SOLID WASTE LANDFILLS ON-SITE, ANY EXPANSIONS OF EXISTING SOLID WASTE LANDFILLS ON-SITE AND ANY EXISTING AREAS OF CONTAMINATION THAT ARE CAPPED PER THE SOLID WASTE RULES.	ACTION
3745-27-18	A-D	SOLID WASTE INCINERATOR & COMPOSTING OPERATIONS	ESTABLISHES OPERATIONAL REQUIREMENTS FOR SOLID WASTE INCINERATORS AND COMPOSTING FACILITIES	PERTAINS TO ANY SITE AT WHICH SOLID WASTE WILL BE EITHER INCINERATED OR COMPOSTED ON-SITE	ACTION
3745-27-19	A-G	OPERATION OF SOLID WASTE DISPOSAL FACILITIES	SPECIFIES GENERAL OPERATIONAL REQUIREMENTS FOR SOLID WASTE LANDFILLS.	SUBSTANTIVE REQUIREMENTS PERTAIN TO ANY NEWLY CREATED SOLID WASTE LANDFILL OR ANY EXPANSION OF AN EXISTING SOLID WASTE LANDFILL ON-SITE.	ACTION

OAC 3745-18	Sulfur dioxide regulations.
OAC 3745-19	Open burning standards; requirements for notification to, and permission from, Ohio EPA.
OAC 3745-21-05	Non-degradation policy: carbon monoxide, ozone, non-methane hydrocarbons.
OAC 3745-21-07	Control of emissions of organic materials from stationary sources (includes a BAT requirement).
OAC 3745-21-08	Control of carbon monoxide emissions.
OAC 3745-21-09	Control of emissions of volatile organic compounds from stationary sources.
OAC 3745-23-04	Non-degradation policy (emissions of nitrogen dioxides to the atmosphere).
OAC 3745-23-06	Control of nitrogen oxides emissions from stationary sources.
OAC 3745-25-03	Emission Control Action Programs: preparation for air pollution alerts, warnings, and emergencies.
OAC 3745-27	Solid waste disposal regulations. Note: attached find a copy of portions of the new solid waste regulations under OAC 3745-27 created by House Bill 592. The revised OAC 3745-27 regulations are only proposed at this point and should be treated as TBC (to be considered) requirements.

These regulations are expected to become final in October, 1989, and will then be official ARAR's. While all of the new regulations in OAC 3745-27 will be ARAR's when finalized, the regulations which will be especially important to the site include:

1. 3745-27-10 Ground Water Monitoring Program.
2. 3745-27-11 Final Closure of Sanitary Landfill Facilities.

3. 3745-27-14 Post-Closure Care of Sanitary Landfill Facilities.

The solid waste landfill siting criteria as stated in OAC 3745-27-06(H)(I) apply only to new landfills created either on-site or off-site.

OAC 3745-31-02	No person shall cause, permit, or allow the installation of a new source of air pollution or a new disposal system....
OAC 3745-31-05	Criteria for decision by the Director. (Plans must demonstrate best available technology, and shall not prevent or interfere with the attainment or maintenance of applicable ambient water quality standards or ambient air quality standards).
OAC 3745-32-02	Section 401 Water Quality Certification required for any licensed activities which may result in any discharge to waters of the State.
OAC 3745-32-05	Criteria for decision by the Director for issuing Section 401 Water Quality Certifications.
OAC 3745-33	Ohio NPDES permits for discharges of pollutants to waters of the State.
OAC 3745-35	Air permits to operate and variances.
OAC 3745-36	Permit requirements for discharges to non-targeted POTWs. (Where a local authorized pre-treatment program is not in place.)
OAC 3745-9	Water well standards for new wells intended for human consumption.
OAC 3745-57-01	Hazardous waste: Environmental Performance Standards. Rule deals with location, design, construction, operation, maintenance, and closure of landfills, waste piles, surface impoundments, and underground injection wells.

OAC 3745-50-48	Requirements for recording and reporting of monitoring results.
OAC 3745-50-62	Trial burn.
OAC 3745-52	Generator standards for hazardous waste which is generated either on-site or off-site.
OAC 3745-53	Transporter standards for hazardous waste shipped off-site.
OAC 3745-54-10 thru -18	General facility standards (permitted facilities).
OAC 3745-54-18	Location standards (seismic and flood plain considerations).
OAC 3745-54-30 thru -37	Preparedness and prevention.
OAC 3745-54-50 thru -56	Contingency plan and emergency procedures.
OAC 3745-54-70 thru -77	Manifest system, recordkeeping, and reporting.
OAC 3745-54-90 thru -99	Ground Water Protection (including ground water protection standard, point of compliance, monitoring program).
OAC 3745-55-01	Corrective Action program for ground water protection.
OAC 3745-55-02	Recordkeeping and reporting.
OAC 3745-55-10 thru -20	Closure and post-closure - new facility standards.
OAC 3745-55-40 thru -51	Financial requirements for closure, post-closure, liability.
OAC 3745-55-70 thru -78	Use and management of containers.
OAC 3745-56-50 thru -60	Waste piles: design and operating requirements.

OAC 3745-55-90 thru 991	Design and operation of tanks.
OAC 3745-56-20 thru -34	Design and operation of surface impoundments.
OAC 3745-56-50 thru -60	Design and operation of waste piles.
OAC 3745-57-01 thru -18	Landfills.
OAC 3745-57-40 thru -51	Incinerators.
OAC 3745-58	Recyclable materials.
OAC 3745-66-11	Closure performance standard.
OAC 3745-66-12	Closure plan; Amendment of Plan.
OAC 3745-66-13	Time allowed for closure.
OAC 3745-66-14	Disposal or decontamination of equipment, structures, and soils.
OAC 3745-66-15	Certification of closure.
OAC 3745-66-16	Survey plat - submittal to local zoning authority.
OAC 3745-66-17	Post-closure care and use of property.
OAC 3745-66-18	Post-closure Plan; Amendment of Plan.
OAC 3745-66-19	Post-closure notices.
OC 3745-66-20	Certification of completion of post-closure care.
OAC 3745-67-28	Surface impoundment closure and post-closure care (note: must also meet performance standard 3745-66-11).
OAC 3745-67-58	Waste pile closure and post-closure care (note: must also meet performance standard 3745-66-11).

OAC 3745-67-80	Land treatment unit closure and post-closure (note: must also meet performance standard 3745-66-11).
OAC 3745-68-10	Landfill closure and post-closure care (note: must also meet performance standard 3745-66-11).
OAC 3745-68-51	Incinerator closure.
OAC 3745-69-04	Closure of chemical, physical, and biological treatment units.
OAC 1501-21	OAC rules for issuing construction permits for and making periodic inspections of dams, dikes, and levees (ODNR).
OAC 3745-81-01 thru -55	Drinking water rules (includes MCL's for inorganic chemicals, organic chemicals, and turbidity).
OAC 3745-82	Secondary contaminant standards.

LIST OF ARAR'S FOR THE
BUCKEYE RECLAMATION LANDFILL

LAWS

ORC 3734.02(F)	No person shall store, treat, or dispose of hazardous waste....
ORC 3734.05(D)(6)(c-d)	The hazardous waste facility board shall not approve an application for a hazardous waste facility installation and operation permit....
ORC 3734.02(H)	No person shall engage in filling, grading, excavating, building, drilling, or mining on land where a hazardous waste facility, or a solid waste facility, was operated without prior authorization from the Director.
ORC 3767	Nuisances: prohibition against noxious exhalations or smells, obstructions or pollution of water courses, other nuisances.
ORC 6111.04	Act of pollution prohibited; exceptions. (Pollution of waters of the State, including surface water and ground water.)
6111.042	Regulations requiring compliance with national effluent standards; other effluent standards may be established on a case by case basis (discharge of pollutants into waters of the State).
ORC 6111.45	Approval of plans for disposal of waste; plan approval by Director required for: any facility which produces, treats, or disposes of industrial waste or materially increases or changes in character any industrial waste, or installs for the treatment or disposal of such waste.
ORC 1521.06 and associated promulgated regulations	No dam, dike, or levee can be constructed in a watercourse unless a construction permit has been issued by the Chief of Division of Water.

MEMORANDUM

SUBJECT: Buckeye Reclamation Landfill ARARs

DATE: June 20, 1990

Ohio EPA promulgated additional regulations pertaining to solid waste landfills on February 12, 1990 (effective March 1, 1990). Consequently, the ARARs list provided to BRLSC and incorporated by M&E in the Revised FS must be updated. Although this issue will be formally raised by Ohio EPA in the comments to the Revised FS, Abby Lavelle and I decided to send you the new solid waste ARARs at this time to provide you with an early start on any changes that may be needed in the Revised FS. Please incorporate the attached addendum to the original ARARs list to bring Ohio EPA's ARARs up-to-date. Do not hesitate to contact me at 644-2924 if you have any questions.

APPENDIX B

DETAILED COST ESTIMATES FOR EACH REMEDIAL ALTERNATIVE

APPENDIX B

A-1. INTRODUCTION

An important step in evaluating different remedial alternatives during a feasibility study is comparing the costs of the various alternatives. To make this comparison, detailed cost estimates are needed for each option that is required for an alternative. This section discusses the methodology used to estimate the alternative costs for the BRL feasibility study and also presents detailed cost estimates for each alternative.

A-2. METHODOLOGY

For each alternative, estimates were obtained for all capital costs and all annual operating and maintenance costs (O&M costs) for that alternative. A determination of the total operating and maintenance costs for the duration of the remedial project was also made. The sum of the total capital costs and the total O&M costs for 30 years, discounted to a base year and expressed as present worth, represents as the total cost of each remedial alternative. The methods used to obtain each type of cost are presented in the sections that follow.

A-2.1. Detailed Capital Costs

Capital costs consist of direct and indirect costs incurred during remediation. Direct costs are primarily construction costs and include any materials, labor, buildings and services, and disposal costs related to construction or one-time remedial options (such as excavation and stabilization of soils, which would only be done once). Direct capital costs were determined by finding a unit cost for each required item and calculating the total direct cost for the required number of units. (For example, a unit price for installing one cubic yard of clay in a multi-layer cap was obtained and the cost for the total volume of clay required for the cap was calculated.)

Indirect capital costs consist of those costs not directly related to construction or implementation of a remedial option. These costs include the price of engineering services and allowances for contingencies and cost escalation (C&E) to cover unforseen occurrences and escalation in the costs for labor, materials, and equipment prior to or during remediation. In the BRL cost estimates, engineering costs were assumed to be 10% of direct capital costs and C&E costs were assumed to be 15% of direct costs. (Source. Handbook Remedial Action at Waste Disposal Sites, U.S. EPA, October 1985).

In the detailed capital cost estimates for this feasibility study, additional costs were also included for any material costs or decreases in productivity due to requirements for additional health and safety protection (e.g., costs of working in Level B, Level C, or Level D personal protection equipment). The following multipliers were applied to the total capital costs (when no special health and safety requirements were considered) to determine the additional costs associated with each level of protection (see Costs of Remedial Actions at Uncontrolled Hazardous Waste Sites, Worker Health and Safety Considerations, U.S. EPA and SCS Engineers, March 1986, for more information):

Level of Protection	Multiplier Used to Obtain Additional Health and Safety Costs
B	1.07
C	0.89
D	0.60

These health and safety costs were included (where applicable) in the total capital cost for each item in each remedial alternative.

The total capital cost for each remedial alternative is the sum of the cost of all capital items needed for that alternative. The total capital cost for each item is the sum of the direct, indirect, and health and safety costs for that item.

A-2.2. Detailed Operating and Maintenance Costs

The O&M costs for each alternative are the sum of the material, service, and labor costs required to perform a long-term remedial task (such as on-site treatment of leachates). These costs include labor costs for annual O&M of any equipment; and costs for treatment chemicals, heating or power required by a remedial option. The O&M costs were determined on an annual basis for each option that requires an O&M component.

A-2.3. Present Worth Analysis

To present the total cost of each remedial alternative in a form that would allow meaningful comparison with other alternatives, a present worth analysis was performed as recommended in Guidance on Remedial Investigations and Feasibility Studies Under CERCLA, U.S. EPA, October 1988. A present worth analysis assumes equal yearly expenditures for O&M during the lifetime of each remedial alternative. This total cost is then discounted to a common base year (usually current dollars). This method allows cost comparisons based on the amount of money that, if invested in the base year and spent as needed, would actually be required to cover all remedial costs over the lifetime of the remedial action.

For the cost estimates presented in this study, present worth analyses were performed for each alternative assuming discount rates (after inflation and before taxes) of 5%. The lifetime (or period of performance) of a remedial alternative was assumed to be 30 years (as recommended in Guidance on Remedial Investigations and Feasibility Studies Under CERCLA, U.S. EPA, October 1988). All O&M costs, unless otherwise specified, for these alternatives were amortized for 30 years. For some alternatives, however, certain remedial actions were assumed to be required for only 5 years (e.g., leachate treatment on site when capping is performed, which dries leachate seeps). For these actions, the present worth analysis was performed for only 5 years.

A-3. COST ESTIMATE SOURCES

Various sources were consulted to obtain detailed cost estimates for remedial alternatives. These sources include vendor quotes, construction cost handbooks, and EPA handbooks and guidance documents. When possible, the cost quoted by a vendor was used for the cost of a specific option with costs from other sources used for verification purposes only. In particular, costs from vendors located near the BRL site were pursued, to negate any deviation from literature costs due to the local availability or absence of materials or services.

A-3.1. Cost Escalation to 1990 Dollars

All cost estimates are presented in 1990 dollars. To escalate costs for materials and services from a base year other than 1988 to 1990 dollars, the plant and equipment indices regularly published in Chemical Engineering magazine (i.e., the Marshall and Swift Equipment Index and the Chemical Engineering Plant Cost Index) were used. To escalate 1988 dollars to 1990 dollars, an inflation rate of 6.2% from 1988 to 1990 was assumed. (Source: Means Site Work Cost Data 1990, RS Means Company, Inc.)

A-4. DETAILED COST RESULTS

The itemized, detailed cost estimates for each remedial alternative are presented in the following tables. Each alternative should have, at a minimum, a summary table presenting the total cost for that remedial alternative, a detailed capital cost breakdown table, and a detailed O&M cost breakdown table.

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for RCRA CAP

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Landfill Preparation						
Compaction testing- field density of soils	$115.86 /day	900 days	$104,270	None	$104,270	EPA
Cut & fill existing material, 300HP dozer, sheepsfoot & roll compactor, 150' haul, 2 passes, 12" lift	$3.38 /cy	11,031,021 cy	$37,284,851	C	$70,468,368	RS Means, 1990
Fence, chain-link, 6' high 3 barb wire, 2" line post @ 10"O.C., 1 5/8" top rail	$11.15 /lf	12,000 lf	$133,800	None	$133,800	RS Means, 1990
Grub stumps, remove, and burn	$1,320 /ac	72 ac	$95,040	None	$95,040	RS Means, 1990
Site clearing, med trees to 12" diam., cut and chip	$3,500 /ac	72 ac	$252,000	None	$252,000	RS Means, 1990
Cap						
Clay, delivered	$19.00 /cy	393,653 cy	$7,479,413	None	$7,479,413	Vendor Quote
Clay installation	$1.27 /cy	393,653 cy	$499,939	C	$944,885	RS Means, 1990
Geomembrane	$3.00 /sf	5,314,320 sf	$15,942,960	None	$15,942,960	Vendor Quote
Sand, delivered	$18.41 /cy	295,240 cy	$5,436,549	None	$5,436,549	Vendor Quote
Sand installation	$0.80 /cy	295,240 cy	$236,192	None	$236,192	RS Means, 1990
Topsoil, delivered	$12.00 /cy	393,653 cy	$4,723,836	None	$4,723,836	Vendor Quote
Topsoil installation	$1.71 /cy	393,653 cy	$673,147	None	$673,147	RS Means, 1990
Revegetation						
Hydraulic spreading (hydroseeding, lime, fertilizer and seed)	$946.90 /ac	122 ac	$115,522	None	$115,522	EPA
Mulching, hay	$345.34 /ac	122 ac	$42,131	None	$42,131	EPA
Erosion Control & Underdrain/Leachate Collection Syst.						
Sand, delivered	$18.41 /cy	681 cy	$12,540	None	$12,540	Vendor Quote
Sand installation	$0.80 /cy	681 cy	$545	None	$545	RS Means, 1990
Topsoil, delivered	$12.00 /cy	3,775 cy	$45,300	None	$45,300	Vendor Quote
Berm installation	$3.38 /cy	3,775 cy	$12,760	None	$12,760	RS Means, 1990
Butt-end fusion machine	$905.00 /day	30 days	$27,150	None	$27,150	Vendor Quote
Erosion control, jute mesh, stapled	$0.95 /sy	590,480 sy	$559,126	None	$559,126	EPA
Excavate earth, 3 cy power shovel, 8 x 20 cy dumptrailers, 2-mile roundtrip	$3.06 /cy	13,557 cy	$41,484	C	$78,406	RS Means, 1990
Filter fabric, polypropylene, laid in trench	$1.66 /sy	9,434 sy	$15,659	C	$29,596	EPA
HDPE underdrain, 36", delivered	$64.05 /lf	9,200 lf	$589,260	None	$589,260	Vendor Quote
Riprap	$21.53 /cy	2,575 cy	$55,440	None	$55,440	RS Means, 1990
Headwall construction	$1,820.00 /ea	2 ea	$3,640	None	$3,640	RS Means, 1990
SUBTOTAL CAPITAL COSTS			$74,382,554		$108,061,875	
QA/QC (5%)			$3,719,128		$5,403,094	
TOTAL CAPITAL COSTS			$78,101,682		$113,464,969	

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for RCRA CAP (cont.)

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Costs
Engineering Design (10%)	$7,810,168	$11,346,497
Construction Management (15%)	$11,715,252	$17,019,745
Startup (10%)	$7,810,168	$11,346,497
Bonds & Permits (2.5%)	$1,952,542	$2,836,624
Legal Fees (3%)	$2,343,050	$3,403,949
Contingencies (20%)	$15,620,336	$22,692,994
TOTAL ADJUSTED CAPITAL COSTS		$182,111,275

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)	Primary Reference
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871	EPA
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545	EPA
Maintenance, grass mowing, level areas	$42.18 /ac-yr	122 ac,30yr	$5,145	$79,099	EPA
Maintenance, refertilization	$269.63 /ac-yr	122 ac,30yr	$32,895	$505,681	EPA
Monitoring:					
Groundwater	$1,760.00 /wl/rd	9 wl,5yr	$31,680	$137,159	Versar
Groundwater	$1,760.00 /wl/rd	14 wl,30yr	$49,280	$757,557	Versar
Leachates	$1,760.00 /wl/rd	2 sta,5yr	$7,040	$30,480	Versar
Leachates	$1,760.00 /wl/rd	2 sta,30yr	$7,040	$108,222	Versar
Surface water	$1,760.00 /wl/rd	3 sta,30yr	$10,560	$162,334	Versar
O&M costs for a revegetated area	$1,463.80 /yr	30 yrs	$1,464	$22,502	EPA
Repairs resulting from freeze/thaw or shrink/swell forces	$230.60 /yr	30 yrs	$231	$3,545	EPA
TOTAL ANNUAL COSTS			$146,143	$1,818,994	

COST SUMMARY	Present Worth (30 yrs, i=5%)
Total Adjusted Capital Costs	$182,111,275
Total Annual Costs	$1,818,994
TOTAL COST ESTIMATE FOR RCRA CAP	$183,930,269

07 Mar

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for STANDARD LANDFILL CAP

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Landfill Preparation						
Compaction testing- field density of soils	$115.86 /day	540 days	$62,562	None	$62,562	EPA
Cut & fill existing material, 300HP dozer, sheepsfoot & roll compactor, 150' haul, 2 passes, 12" lift	$3.63 /cy	1,310,000 cy	$4,755,300	C	$8,987,517	RS Means, 1990
Fence, chain link, 6' high 3 barb wire, 2" line post @ 10"O.C., 1 5/8" top rail	$11.15 /lf	12,000 lf	$133,800	None	$133,800	RS Means, 1990
Site clearing, med trees to 12" diam., cut and chip	$3,500.00 /ac	37 ac	$129,500	None	$129,500	RS Means, 1990
Grub stumps and remove, burn	$2,200.00 /ac	37 ac	$81,400	None	$81,400	RS Means, 1990
Cap						
Clay, delivered, spread, compacted	$19.00 /cy	280,720 cy	$5,333,680	None	$5,333,680	Vendor Quote
Clay installation	$1.27 /cy	280,720 cy	$356,514	C	$673,812	RS Means, 1990
Sand, delivered	$18.41 /cy	140,360 cy	$2,584,589	None	$2,584,589	Vendor Quote
Sand installation	$0.80 /cy	140,360 cy	$112,288	None	$112,288	RS Means, 1990
Topsoil, delivered, spread, compacted	$12.00 /cy	280,720 cy	$3,368,640	None	$3,368,640	Vendor Quote
Topsoil installation	$1.71 /cy	280,720 cy	$480,031	None	$480,031	RS Means, 1990
Revegetation						
Hydraulic spreading (hydroseeding, lime, fertilizer and seed)	$946.90 /ac	87 ac	$82,380	None	$82,380	EPA
Mulching, hay	$345.34 /ac	87 ac	$30,045	None	$30,045	EPA
Erosion Control						
Berm installation	$3.48 /cy	5,250 cy	$18,270	None	$18,270	RS Means, 1990
Erosion control, jute mesh, stapled	$0.95 /sy	179,080 sy	$169,571	None	$169,571	EPA
Excavate earth, 3 cy power shovel, 8 x 20 cy dumptrailers, 2-mile roundtrip	$3.06 /cy	7,765 cy	$23,761	C	$44,908	RS Means, 1990
Filter Fabric, polypropylene	$1.66 /sf	50,600 sf	$83,996	None	$83,996	EPA
Riprap	$21.53 /cy	2,811 cy	$60,521	None	$60,521	RS Means, 1990
SUBTOTAL CAPITAL COSTS			$17,866,848		$22,437,510	
QA/QC (5%)			$893,342		$1,121,876	
TOTAL CAPITAL COSTS			$18,760,191		$23,559,386	

ADDENDUM TO OHIO ADMINISTRATIVE CODE (OAC) ARARS - SOLID WASTE REGULATIONS FOR [illegible] LANDFILL

OAC CITATION	PERTINENT PARAGRAPHS	TITLE / SUBJECT OF REGULATION	DESCRIPTION OF REGULATION	APPLICATION OF REGULATION	ARAR TYPE
3745-27-05	A,B,C	AUTHORIZED, LIMITED & PROHIBITED SOLID WASTE DISPOSAL	ESTABLISHES ALLOWABLE METHODS OF SOLID WASTE DISPOSAL ; SANITARY LANDFILL, INCINERATION, COMPOSTING. PROHIBITS MANAGEMENT BY OPEN BURNING AND OPEN DUMPING.	PERTAINS TO ANY SITE AT WHICH SOLID WASTES WILL BE MANAGED.	
3745-27-06	B,C	REQUIRED TECHNICAL INFO FOR SANITARY LANDFILLS	SPECIFIES THE MINIMUM TECHNICAL INFORMATION REQUIRED OF A SOLID WASTE PTI. INCLUDED ARE A HYDROGEOLOGIC INVESTIGATION REPORT, LEACHATE PRODUCTION AND MIGRATION INFORMATION, SURFACE WATER DISCHARGE INFORMATION, DESIGN CALCULATIONS, PLAN DRAWINGS, CONSTRUCTION PLANS AND OPERATIONAL PLANS.	THIS PARAGRAPH PRESENTS SUBSTANTIVE REQUIREMENTS OF A SOLID WASTE PTI, WHICH PERTAIN TO ANY NEW SOLID WASTE DISPOSAL FACILITY CREATED ON-SITE AND EXPANSIONS OF EXISTING SOLID WASTE LANDFILLS. PORTIONS ALSO PERTAIN TO EXISTING AREAS OF CONTAMINATION THAT ARE CAPPED PER SOLID WASTE RULES. THIS RULE ESTABLISHES THE MINIMUM INFORMATION REQUIRED DURING THE REMEDIAL DESIGN STAGE.	ACTION
3745-27-07	A,B	LOCATION CRITERIA FOR SOLID WASTE DISPOSAL PERMIT	SPECIFIES LOCATIONS IN WHICH SOLID WASTE LANDFILLS ARE NOT TO BE SITED. INCLUDES FLOODPLAINS, SAND OR GRAVEL PITS, LIMESTONE OR SANDSTONE QUARRIES, AREAS ABOVE SOLE SOURCE AQUIFERS, WETLANDS, ETC.	THIS RULE LIMITS THE ESTABLISHMENT OF NEW SOLID WASTE LANDFILLS AND EXPANSIONS OF EXISTING SOLID WASTE LANDFILLS IN CERTAIN UNFAVORABLE LOCATIONS. ALSO MAY LIMIT THE LEAVING OF WASTE IN-PLACE IN CERTAIN UNFAVORABLE LOCATIONS.	LOCATION
3745-27-08	C,D,E	CONSTRUCTION SPECS FOR SANITARY LANDFILLS	SPECIFIES THE MINIMUM REQUIREMENTS FOR THE SOIL/CLAY LAYERS, GRANULAR DRAINAGE LAYER, GEOSYNTHETICS, LEACHATE MANAGEMENT SYSTEM, GAS MONITORING SYSTEM, ETC. ALSO ESTABLISHES CONSTRUCTION REQUIREMENTS FOR FACILITIES TO BE LOCATED IN GEOLOGICALLY UNFAVORABLE AREAS.	PERTAINS TO ANY NEW SOLID WASTE DISPOSAL FACILITY CREATED ON-SITE AND ANY EXPANSIONS TO EXISTING SOLID WASTE LANDFILLS. PORTIONS ALSO PERTAIN TO EXISTING AREAS OF CONTAMINATION THAT WILL BE CAPPED IN-PLACE PER SOLID THE WASTE RULES. MAY SERVE AS SITING CRITERIA.	ACTION, LOCATION
3745-27-09	C-F,I,L-O	SANITARY LANDFILL OPERATIONAL REQUIREMENTS	SPECIFIES OPERATIONAL REQUIREMENTS FOR SOLID WASTE LANDFILLS. INCLUDES LEACHATE AND AIR EMISSION MANAGEMENT, FILLING OF NEW PHASE, ACCESS ROADS, DAILY COVER, SCREENING WASTE, LAYER THICKNESS, DISPOSAL OF LIQUIDS	PERTAINS TO NEW SOLID WASTE DISPOSAL FACILITIES TO BE CREATED ON-SITE AND EXISTING LANDFILLS THAT WILL EXPANDED DURING REMEDIATION. PORTIONS ALSO PERTAIN TO EXISTING AREAS OF CONTAMINATION THAT WILL BE CAPPED	ACTION

07-Mar-'

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for STANDARD LANDFILL CAP (cont.)

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Cost
Engineering Design (10%)	$1,876,019	$2,355,939
Construction Management (15%)	$2,814,029	$3,533,908
Startup (10%)	$1,876,019	$2,355,939
Bonds & Permits (2.5%)	$469,005	$588,985
Legal Fees (3%)	$562,806	$706,782
Contingencies (20%)	$3,752,038	$4,711,877
TOTAL ADJUSTED CAPITAL COSTS		$37,812,814

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)	Primary Reference
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871	EPA
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545	EPA
Maintenance, grass mowing, level areas	$42.18 /ac-yr	37 ac,30yr	$1,561	$23,989	EPA
Maintenance, grass mowing, sloped areas	$101.05 /ac-yr	50 ac,30yr	$5,052	$77,670	EPA
Maintenance, refertilization	$269.63 /ac-yr	87 ac,30yr	$83,291	$360,609	EPA
Monitoring:					
Groundwater	$1,760.00 /wl/rd	9 wl,5yr	$31,680	$137,159	Versar
Groundwater	$1,760.00 /wl/rd	14 wl,30yr	$49,280	$757,557	Versar
Leachates	$1,760.00 /wl/rd	2 sta,5yr	$7,040	$30,480	Versar
Leachates	$1,760.00 /wl/rd	2 sta,30yr	$7,040	$108,222	Versar
Surface water	$1,760.00 /wl/rd	3 sta,30yr	$10,560	$162,334	Versar
O&M costs for a revegetated area	$1,463.80 /yr	30 yrs	$1,464	$22,502	EPA
Repairs resulting from freeze/thaw or shrink/swell forces	$230.60 /yr	30 yrs	$231	$3,545	EPA
TOTAL ANNUAL COSTS			$198,006	$1,696,481	

COST SUMMARY	Present Worth (30 yrs, i=5%)
Total Adjusted Capital Costs	$37,812,814
Total Annual Costs	$1,696,481
TOTAL COST ESTIMATE FOR STANDARD LANDFILL	$39,509,295

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for GROUNDWATER COLLECTION (UNDERDRAIN) SYSTEM

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Backfill earth, 300HP dozer & roller compactors, 150' hau 8" lift, 2 passes	$0.80 /cy	1,623 cy	$1,298	C	$2,454	RS Means, 1990
Butt-end fusion machine	$500.00 /day	8 days	$4,000	C	$7,560	Vendor Quote
Excavate earth, 3 cy power shovel, 8 x 20 cy dumptrailers 2-mile roundtrip	$3.06 /cy	3,208 cy	$9,816	C	$18,553	RS Means, 1990
Filter fabric, polypropylene, laid in trench	$1.66 /sy	4,650 sy	$7,718	C	$14,588	EPA
HDPE underdrain, 10", delivered	$6.14 /lf	1,125 lf	$6,908	None	$6,908	Vendor Quote
HDPE perforated underdrain, 10", delivered	$6.78 /lf	4,650 lf	$31,527	None	$31,527	Vendor Quote
Sand, delivered	$18.41 /cy	320 cy	$5,892	None	$5,892	Vendor Quote
Sand installation	$0.80 /cy	320 cy	$256	C	$484	RS Means, 1990
SUBTOTAL CAPITAL COSTS			$67,416		$87,966	
QA/QC (5%)			$3,371		$4,398	
TOTAL CAPITAL COSTS			$70,787		$92,364	

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Cost
Engineering Design (10%)	$7,079	$9,236
Construction Management (15%)	$10,618	$13,855
Startup (10%)	$7,079	$9,236
Bonds & Permits (2.5%)	$1,770	$2,309
Legal Fees (3%)	$2,124	$2,771
Contingencies (20%)	$14,157	$18,473
TOTAL ADJUSTED CAPITAL COSTS		$148,244

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545
O&M costs for a revegetated area	$1,463.80 /yr	30 yrs	$1,464	$22,502
TOTAL ANNUAL COSTS			$2,271	$34,918

COST SUMMARY	Present Worth (30 yrs, i=5%)
Total Adjusted Capital Costs	$148,244
Total Annual Costs	$34,918
TOTAL COST ESTIMATE FOR UNDERDRAIN SYSTEM	$183,162

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for LEACHATE COLLECTION (FRENCH DRAIN) SYSTEM

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Backfill, compacted, vibrating roller, 6-12" lifts	$1.27 /cy	643 cy	$817	C	$1,543	RS Means, 1990
Butt-end fusion machine	$500.00 /day	5 days	$2,500	C	$4,725	Vendor Quote
Filter fabric, polypropylene, laid in trench	$1.66 /sy	1,523 sy	$2,528	C	$4,778	RS Means, 1990
Gravel envelope, crushed bank run, screened (.75in. to .5	$11.75 /cy	967 cy	$11,365	C	$21,480	RS Means, 1990
HDPE underdrain, 4"	$1.70 /lf	1205 lf	$2,049	None	$2,049	Vendor Quote
HDPE perforated underdrain, 4"	$1.87 /lf	9 lf	$17	None	$17	Vendor Quote
Sand, delivered	$18.41 /cy	825 cy	$15,192	None	$15,192	Vendor Quote
Sand installation	$0.80 /cy	825 cy	$660	C	$1,247	RS Means, 1990
SUBTOTAL CAPITAL COSTS			$35,126		$51,030	
QA/QC (5%)			$1,756		$2,552	
TOTAL CAPITAL COSTS			$36,883		$53,582	

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Cost
Engineering Design (10%)	$3,688	$5,358
Construction Management (15%)	$5,532	$8,037
Startup (10%)	$3,688	$5,358
Bonds & Permits (2.5%)	$922	$1,340
Legal Fees (3%)	$1,106	$1,607
Contingencies (20%)	$7,377	$10,716
TOTAL ADJUSTED CAPITAL COSTS		$85,999

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)	Primary Reference
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871	EPA
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545	EPA
O&M costs for a revegetated area	$1,463.80 /yr	30 yrs	$1,464	$22,502	EPA
TOTAL ANNUAL COSTS			$2,271	$34,918	

COST SUMMARY	Present Worth (30 yrs, i=5%)
Total Adjusted Capital Costs	$85,999
Total Annual Costs	$34,918
TOTAL COST ESTIMATE FOR LEACHATE COLLECTION	$120,916

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for CHEMICAL TREATMENT

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Aerator	$2,500.00 /unit	1 unit	$2,500	None	$2,500	Vendor Quote
Berm installation	$338.00 /cy	2,644 cy	$893,672	None	$893,672	RS Means, 1990
Clay, delivered	$19.00 /cy	1,427 cy	$27,113	None	$27,113	Vendor Quote
Clay installation	$1.27 /cy	1427 cy	$1,812	None	$1,812	RS Means, 1990
Excavate earth, 3 cy power shovel, 8 x 20 cy dumptrailers 2-mile roundtrip	$3.06 /cy	17,742 cy	$54,291	None	$54,291	RS Means, 1990
Geomembrane	$3.00 /sf	38,514 sf	$115,542	None	$115,542	Vendor Quote
Lime plant	$150,000.00 /plant	1 plant	$150,000	None	$150,000	Vendor Quote
Lime plant building	$35,000.00 /bldg	1 bldg	$35,000	None	$35,000	Vendor Quote
Riprap	$21.53 /cy	37 cy	$797	None	$797	RS Means, 1990
Topsoil, delivered	$12.00 /cy	714 cy	$8,568	None	$8,568	Vendor Quote
Topsoil installation	$1.27 /cy	714 cy	$907	None	$907	RS Means, 1990
SUBTOTAL CAPITAL COSTS			$1,290,201		$1,290,201	
QA/QC (5%)			$64,510		$64,510	
TOTAL CAPITAL COSTS			$1,354,711		$1,354,711	

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Cost
Engineering Design (10%)	$135,471	$135,471
Construction Management (15%)	$203,207	$203,207
Startup (10%)	$135,471	$135,471
Bonds & Permits (2.5%)	$33,868	$33,868
Legal Fees (3%)	$40,641	$40,641
Contingencies (20%)	$270,942	$270,942
TOTAL ADJUSTED CAPITAL COSTS		$2,174,312

07-Mar--

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for CHEMICAL TREATMENT (cont.)

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)	Primary Reference
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871	EPA
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545	EPA
Operational Costs:					
Labor	$25.00 /hr	1,000 hrs/yr	$25,000	$384,313	
Sludge dredging and dewatering	$0.20 /gal	1.426E+06 gal/yr	$285,200	$4,384,237	
Sludge transporation and disposal	$311,880.00 /yr	30 yrs	$311,880	$4,794,375	Vendor Quote
Lime (hydrated, dry)	$79.00 /ton	765 ton/yr	$60,435	$929,037	
TOTAL ANNUAL COSTS			$683,323	$10,504,377	

COST SUMMARY	Present Worth (30 yrs, i=5%)
Total Adjusted Capital Costs	$2,174,312
Total Annual Costs	$10,504,377
TOTAL COST ESTIMATE FOR CHEMICAL TREATMENT	$12,678,689

07-Mar-

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for WETLANDS

CAPITAL COST ITEMS	Unit Cost	Quantity	Subtotal Cost	Health & Safety Level of Protection	Capital Costs	Primary Reference
Wetland Construction						
Cattail installation	$25,000.00 /ac	18 ac	$450,000	None	$450,000	
Clay, delivered	$19.00 /cy	29,040 cy	$551,760	None	$551,760	Vendor Quote
Clay installation	$1.27 /cy	29,040 cy	$36,881	None	$36,881	RS Means, 1990
Dike installation	$3.48 /cy	3,727 cy	$12,970	None	$12,970	RS Means, 1990
Excavate earth, 3 cy power shovel, 8 x 20 cy dumptrailers 2-mile roundtrip	$3.06 /cy	145,200 cy	$444,312	None	$444,312	RS Means, 1990
Geomembrane	$3.00 sf	784,080 sf	$2,352,240	None	$2,352,240	Vendor Quote
Limestone (Crushed)	$25.00 /cy	29,040 cy	$726,000	None	$726,000	RS Means, 1990
Riprap	$21.53 /cy	50 cy	$1,077	None	$1,077	RS Means, 1990
Sand, delivered	$18.41 /cy	29,040 cy	$534,743	None	$534,743	Vendor Quote
Sand installation	$0.80 /cy	29,040 cy	$23,232	None	$23,232	RS Means, 1990
Revegetation						
Hydraulic spreading (hydroseeding, lime, fertilizer and seed)	$946.90 /ac	2 ac	$1,610	None	$1,610	EPA
Mulching, hay	$345.34 /ac	2 ac	$587	None	$587	EPA
SUBTOTAL CAPITAL COSTS			$5,135,411		$5,133,214	
QA/QC (5%)			$256,771		$256,661	
TOTAL CAPITAL COSTS			$5,392,181		$5,389,875	

ADJUSTMENTS TO CAPITAL COSTS	Subtotal Cost	Capital Cost
Engineering Design (10%)	$539,218	$538,987
Construction Management (15%)	$808,827	$808,481
Startup (10%)	$539,218	$538,987
Bonds & Permits (2.5%)	$134,805	$134,747
Legal Fees (3%)	$161,765	$161,696
Contingencies (20%)	$1,078,436	$1,077,975
TOTAL ADJUSTED CAPITAL COSTS		$8,650,749

23-Apr-9'

Buckeye Reclamation Landfill
Project No. 6022.8.2
Cost Worksheet for WETLANDS (cont.)

ANNUAL COSTS	Unit Cost	Quantity	Annual Cost	Present Worth (30 yrs, i=5%)	Primary Reference
Inspection, annual	$577.05 /yr	30 yrs	$577	$8,871	EPA
Maintenance, erosion control and drainage	$230.60 /yr	30 yrs	$231	$3,545	EPA
O&M costs for a revegetated area	$1,463.80 /yr	30 yrs	$1,464	$22,502	EPA
TOTAL ANNUAL COSTS			$2,271	$34,918	

PERIODIC COSTS	Unit Cost	Year	Present Worth (i=5%)
Cattail Revegetation	$230,000	15	$110,630
	$230,000	30	$53,222
			$163,852

COST SUMMARY	Present Worth (, i=5%)
Total Adjusted Capital Costs	$8,650,749
Total Annual Costs	$34,918
Total Periodic Costs	$163,852
TOTAL COST ESTIMATE FOR WETLANDS	$8,849,518

ADDENDUM

This addendum contains modifications to the following eight sections of text and appendices C through K which, together with this addendum, comprise the Feasibility Study Report for the Ormet Corporation Superfund Site located in Hannibal, Ohio.

I. GENERAL MODIFICATIONS

1. GROUNDWATER

Throughout the body of this report and in Section 5 of Appendix F, this report suggests that alternate cleanup levels (ACLs), as provided in Section 121 (d)(2)(B)(ii) of CERCLA, may be appropriate for cleanup of the contaminated ground water at this site. Based upon currently available information, implementation of the alternatives in this report to achieve cleanup levels set forth in the Safe Drinking Water Act (MCLs and MCLGs), is practicable. Therefore, pursuant to the NCP, ACLs are not appropriate for this site. The preamble to the NCP provides:

> "EPA interprets the CERCLA Section on ACLs not as an entitlement, but rather as a limitation on the use of levels in excess of standards that would otherwise be appropriate for a site. Although the limitation refers only to areas outside the facility boundary, EPA maintains that the same principle holds within the boundary (to the edge of any waste management area left at the site), namely that such ACLs should only be used when active restoration of the ground water to MCLs or non-zero MCLGs is not practicable."

55 Fed. Reg. 8754 (March 8, 1990)

Additionally, Section 6 of this report repeatedly states that there is no existing risk associated with ground water at the site. Under current land use and engineering controls in place, exposure to ground water is limited. Absent such controls, however, and under potential future land use scenarios, there is risk associated with exposure to the contaminated ground water, as demonstrated in the Baseline Risk Assessment. The carcinogenic risks posed to the future resident were quantified at 2E-03 and 10 for noncarcinogenic risks. (See RI Report Appendix R Table ES-5 and Table ES-8 for more details). There is no guarantee that Ormet Corporation will be operating for many years into the future and, therefore, there is no guarantee that the Ranney well and existing interceptor wells will be continued for a certain number of years. Conclusively, active remedial response is an appropriate alternative to consider for remediation of the contaminated ground water. See the discussion on the appropriate utilization of institutional controls in the Appendix F modifications cited below.

2. <u>OAC 3745-54-18</u>

Alternatives which include component CMSD-4, CMSD-5, CMSD-7, or CMSD-8 include the use of rip rap or concrete revetments to protect against washout of hazardous waste from a one-hundred-year floodplain, as required by OAC 3745-54-18. As currently presented, however, these engineering controls do not meet this potential ARAR. Specifically, the use of freeboard, which may be necessary because of wave action in the Ohio River was not considered. Additionally, the alternatives presented rely upon what may be an existing levee, but this levee has not yet been characterized to confirm its existence or that it would protect the CMSD from a 100-year flood event. Finally, alternatives which create CMSD seep collection trenches and sumps also must be designed so as to be protected from a 100-year flood event. These considerations, including concerns/issues resulting from the anticipated consultation with the State of Ohio, will be taken into account during design of the remedy in order to assure compliance with OAC 3745-54-18. This also modifies similar language in the following sections of this document:

* Section 4.3.5.4, Page 4-90, Paragraph 1 & 2
* Section 4.3.5.4, Page 4-92, Paragraph 1
* Section 4.3.5.5, Page 4-92, Paragraph 1
* Section 5.5.5, Page 5-34
* Section 6.3.1.2, Page 6-14, Paragraph 1
* Section 6.5.1.2, Page 6-89, Paragraph 1
* Section 7.1.2, Page 7-20, Paragraph 1
* Section 7.2, Page 7-21, Paragraph 1

3. <u>**VEGETATIVE SOIL COVERS**</u>

In regards to Ormet's discussions on the utilization of vegetative soil covers for the FSPSA, the FDPs and CMSD source areas, U.S. EPA has modified the text to state that routine maintenance of the vegetative soil covers proposed for the FSPSA, FDPs, and the CMSD source areas would be implemented to prevent exposure to environmental receptors (i.e. mammals and phytotoxicity) from the penetration of the cover by burrowing animals and trees. Accordingly, the Operation and Maintenance (O&M) costs associated with the added dimension of this particular remedial measure will remain categorized in the low to moderate cost range as state in the text. Therefore, the text does not require any modifications regarding O&M costs. Additionally, the text is modified to state that vegetative soil covers will not comply with the closure standards in OAC 3745-27-11(G) for closing areas containing solid waste. This discussion also modifies similar language in Section 4.3.3.2, Page 4-37, "CONCLUSION", last sentence, Section 4.3.4.2, Page 4-64 and Section 4.3.5.3, Page 4-88.

4. **RCRA SINGLE BARRIER CLAY CAPS vs. RCRA SINGLE BARRIER SYNTHETIC FML CAPS vs. RCRA DUAL BARRIER CAPS**

The distinctions between the two single barrier caps are cited below:

Two types of single barrier caps are under consideration for use in alternatives requiring containment of contaminant source areas (i.e. FSPSA, FDPs, & CMSD). The differences between the two single barrier caps considered is that one utilizes a recompacted clay layer for the barrier and the other uses a synthetic Flexible Membrane Liner (FML) for the barrier. A cap which incorporates a properly constructed clay barrier is structurally more durable than an FML and therefore, is more reliable in the long term. Overall, a clay cap is not as susceptible to tears, cuts, perforations or seam failures as are synthetic FMLs.

On Pages 6-55, 6-128, 6-164, 6-210, 6-256, and 6-296, the text provides that the synthetic FML cap will meet OAC:3745-27-11(G)(1), which pertains to closure of solid waste landfills. This is also true for the single barrier clay cap, as indicated on Page 6-345. While the intent to meet this ARAR is clear, the conceptual drawings of the single barrier caps do not demonstrate that this ARAR is met. However, should a remedy which incorporates such be selected, then during remedial design, the conceptual drawings will be refined to ensure that the construction of the cap meets the requirements stated in the ARAR. For purposes of determining whether or not the FML and single barrier clay caps meet the Ohio ARAR, as currently presented in the conceptual drawings in Section 5, they do not. A cap will, however, be designed to meet this ARAR if it is part of the selected remedy.

To combine the advantages of both the clay cap and the FML, a dual barrier cap could be employed. This cap would utilize a recompacted clay layer and an FML. Dual barrier caps are inherently more reliable due to structural redundancy and are typically used to contain hazardous waste. This discussion also modifies similar language found in Table 7-4, Page 7-37, "LONG-TERM RELIABILITY", Sentence #6 and Section 7.4.3, Page 7-47, Paragraph 1, Sentence #8.

5. APPENDIX K

Despite the conservative assumptions (i.e. the hypothetical placement of only two wells to intercept the plume, the estimates for maximum drawdown and/or the total pumping rate in Hypothetical wells #1 and #2, the assumptions that the 13% decrease in total cyanide removal will remain continuous over time and that the leveling off of total cyanide concentrations will occur at a value below 0.1 mg/l,etc...) made by Ormet Corporation in its calculations of aquifer restoration periods, this appendix demonstrates that extraction wells placed closer to the Former Spent Potliner Storage Area (FSPSA) source area would remove cyanide at higher concentrations under GW-5 than under GW-3. Accordingly, Appendix K is modified to state the following:

(1). The remediation of the FSPSA through treatment and/or containment will further decrease the amount of time necessary to restore the Ohio River Valley aquifer to its beneficial use through the implementation of either alternatives GW-3 or GW-5.

(2). It is likely that some combination of alternatives GW-3 and GW-5, in conjunction with treatment and/or containment of the FSPSA would provide an efficient means of ground water restoration. However, if alternatives GW-3, GW-5, or a combination of such become a component of the Record of Decision (ROD), selection of the exact number of wells and the optimal locations of these wells will be refined in the Remedial Design Phase of this project.

(3). It should be noted that, if only GW-3 <u>or</u> Gw-5 is implemented, achievement of Maximum Contamination Levels (MCLs) will take approximately four (4) decades, whereas it is anticipated that the <u>combination</u> of alternatives GW-3 and GW-5 may achieve MCLs in a lesser amount of time.

(4). Well placement (i.e. at the center of the plume or at plume boundary) for a ground water remedial action may or may not affect Ormet's ability to attain the substantive requirements of the existing NPDES permit. Consequently, a treatability study to determine BAT for the new surface water discharge may be necessary to establish any modifications to the existing NPDES permit. Although, Ormet Corporation states in this document that this may cause delays for up to three years, U.S. EPA believes the implementation of a treatability study can be completed within a shorter period of time. This paragraph also modifies similar language in the following sections of this document:

* Section 3.2.1.3, Page 3-7, Paragraph 3, Sentences #4, #5 & #6

* Section 6.10.1.1, Page 291, Paragraph 1, Sentence #1

* Section 7.3.1, Page 7-31, Paragraph 4, Sentence #4

* Sections 7.6.4 and 7.6.5 and Table 7-6, Pages 7-65 and 7-66

6. **APPENDIX F**

Appendix F is modified as follows:

A. **INSTITUTIONAL CONTROLS**

Section 3.2 of Appendix F is modified to reflect consistency with CERCLA and the NCP with respect to the use of institutional controls at Superfund sites. "Remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants as a principal element, are to be preferred over remedial actions not involving such treatment." [Section 121 (a) of CERCLA, 42 U.S.C. § 9621(a)]. Additionally, the preamble to the NCP provides that "institutional controls should not substitute for active response measures as the sole remedy unless such active measures are determined to be not practicable [based upon an evaluation of the 9 criteria]". (55 Fed. Reg. 8702 (March 8, 1990). Because the effectiveness of institutional controls is uncertain and because CERCLA and the NCP reflect a preference for treatment, the calculation of health-based goals for ground water, sediments and soils is warranted.

Furthermore, alternatives which employ containment and treatment technologies presented in this report are suitable to this site. Therefore, institutional controls will be considered only to supplement engineering controls and active remedial responses with respect to the contaminated soils on site, ground water underlying the site, and sediments in the Outfall 004 backwater area. This also modifies similar language in the following sections of this document:

* Section 2.11.2.1, Page 2-81, Paragraph 1
* Section 6.3.4.3, Page 6-29, Paragraph 1, Sentence #1
* Section 6.10.4.4, Page 6-316, Paragraph 1, Sentence #6
* Section 6.11.4.4

B. PCB-CONTAMINATED SEDIMENTS

The discussion of PCB-contaminated sediments relating to ARARs/*To-be-Considered (TBCs) presented in Appendix F* is clarified below:

TSCA and 40 CFR Part 761.60 are potentially action-specific ARARs because they regulate the storage and disposal of PCB-contaminated material. The PCB Spill Policy (40 CFR §§ 761.120 - 761.139) is TBC for determining the level of cleanup of PCB-contaminated materials (soils -- 1ppm residential, 10-25 ppm industrial; sediments -- SQC). Additionally, the "Guidance on Remedial Actions for Superfund Sites with PCB Contamination", OSWER Directive # 9355.4-01 (August 1990), is TBC for determining cleanup levels for PCB-contaminated sediments. It provides that PCB concentrations of 100 ppm in residential areas, and 500 ppm *in industrial areas represent principal threats that should* be treated, while lower concentrations should be managed and contained. These TBCs are not required cleanup levels, but they may be "very useful in helping to determine what is protective at a site, or how to carry out certain actions or requirements". See preamble to the NCP at 55 Fed. Reg. 8745 (March 8, 1990).

C. REMEDIAL ACTION GOALS/LEVELS

The Agencies in the Record of Decision (ROD) will select a remedy for the Ormet Corporation Site. The Agencies will utilize the information obtained during the RI/FS to select a remedial alternative that satisfies the "threshold criteria" of the NCP: protection of human health and the environment, and compliance with chemical-specific, action-specific (e.g., technology or performance-based standards) and location-specific applicable and/or relevant and appropriate regulations (ARARs). However, this decision cannot be made until the Agencies have evaluated the appropriate remedial action goals/levels which must be met by the selected remedy. Ormet Corporation has utilized one approach to develop what it believes are the appropriate remedial action goals for this site. Ormet's approach fails to incorporate risk-based clean-up goals as the Remedial

Action Goals (RAGs) for the site. Rather, Ormet relies on institutional controls to support its position that risk-based goals are not warranted, except for soils in an industrial use scenario. As discussed in General Modification #6A, Ormet's reliance upon institutional controls as a sole remedy for ground water and sediments is inconsistent with NCP. U.S. EPA is appending an alternate approach that may be considered by the Agencies when selecting remediation levels in the ROD (See Attachment #1 for more details). Risk-based RAGs are warranted for this site. Therefore, this discussion modifies Section 3.2 and Section 5.0 of Appendix F.

Additionally, it should be noted that the preliminary goals proposed by Ormet Corporation in this appendix did not include and/or consider the following items:

* Additivity among chemicals within an exposure pathway for the soil, groundwater and sediment;
* Subchronic exposures to future residential children in groundwater;
* Dermal Route of exposure to PCB contaminated sediments, because this was not a requirement of the method utilized by Ormet Corporation;
* Ormet Corporation did not utilize the same ingestion rate of sediments as did U.S. EPA in the Baseline Risk Assessment (BRA). Ormet used a much higher/more conservative ingestion rate which would yield a higher RAG than that calculated by the U.S. EPA;
* Ormet Corporation has a mathematical error in the PAH remedial action goal calculations for sediments. U.S. EPA could not reproduce Ormet Corporations's calculations.

There are several different sources used to develop remedial goals and clean up standards, (e.g. health-based goals, ARARs, analytical method detection limits, background levels, etc....). The selected goals and standards will be documented in the ROD. Table F-13 and Attachment #1 of this Addendum indicate the clean up standards that will be considered by the Agencies when selecting the final site remedy.

7. **REMEDIAL MEASURES SED-6 AND SED-8**

The effectiveness of the installation of sheet piling and concrete revetments, over contaminated sediments left in place in the backwater area, to either eliminate, contain or reduce exposure pathways for ecological receptors is uncertain, however, the direct contact exposure pathways to humans may be effectively blocked. More specifically, all effectiveness discussions of Remedial Measures SED-6 and SED-8, are modified to the preceding sentence because (1). the hydraulic isolation for these contaminated sediments may not be achieved, (2). the permanence of this technology has not be proven and (3). the potential leachability of aqueous phase contaminants exists. The following sections of this document are also modified to the first sentence of this paragraph:

* Section 4.3.7.6, Page 4-126, "EFFECTIVENESS" discussion, 1st, 4th & 6th Sentences
* Section 4.3.7.6, Page 4-128, "CONCLUSION", Sentence #3
* Section 4.3.7.8, Page 4-134, "CONCLUSION", 1st Sentence
* Section 6.3.2, Page 6-18, Paragraph 2, Sentences #1 & #2
* Sections 6.4.2, 6.6.2, and 6.9.2
* Section 7.3.4, Page 7-33, Paragraph 1, Sentence #3
* Table 7-4, Pages 7-35 to 7-43, "REDUCTION OF ASSUMED EXISTING RISKS" discussions for Alternatives 2 through 10
* Section 7.4.3, Page 7-47, Paragraph 1, Sentence #11

II. SPECIFIC MODIFICATIONS

1. Section 4.0 ASSEMBLY AND SCREENING OF REMEDIAL MEASURES

* Section 4.3.1.3, Page 4-14, Paragraph 1, Sentence #3 is modified, because this "EFFECTIVENESS" discussion fails to clearly indicate that the contaminant plume size will not be reduced under remedial measure GW-3. Therefore, the aforementioned sentence has been modified to read:

  "This measure would continue to contain the mobility and migration of the plume and its constituents although plume size would not be reduced. This measure will only contain the plume on-site. However, this measure will continue to allow the plume to extend 2700 feet away from the source, thus contaminating a large portion of the aquifer."

* Section 4.3.3.2, Page 4-36, Paragraph 1, 2nd & 3rd Sentences are modified, because this "EFFECTIVENESS" discussion fails to specify exactly how the risk-based criteria for all medias (i.e. soil, air, and ground water) will be met during the implementation of remedial measure FSPSA-2. Therefore, the aforementioned sentences have been modified to read:

  "This remedial measure would not significantly reduce the toxicity, mobility, or volume of constituents within the Former Spent Potliner Storage Area (FSPSA) or reduce infiltration of contaminants into the groundwater medium. However, this remedial measure would meet the soil risk-based criteria by blocking direct contact and air transport pathways."

  NOTE: The aforementioned language also revises the pertinent "EFFECTIVENESS" discussions for remedial measures FDP-2 and CMSD-3 (i.e. Section 4.3.4.2, Page 4-64 and Section 4.3.5.3, Page 4-88, respectively).

* Section 4.3.7.7, Page 4-129, Paragraph 2, is modified to include the following statement between the 4th and 5th sentences:

  "Since the current location of the 004 Outfall may interfere with remedial actions in the backwater areas and the CRDA, the 004 Outfall may need to be relocated outside of the CRDA and backwater areas."

2. **SECTION 5.0 DEVELOPMENT OF SITEWIDE ALTERNATIVES**

* Section 5.10.1, Page 5-60, Paragraph 1, Sentence #1 is modified, because the text fails to identify the purpose of installing the hypothetical interceptor wells closer to the FSPSA contaminant source area. Therefore, the aforementioned sentence has been modified to read:

  "New interceptor wells would be installed closer to the source of the plume to remove contaminant mass from ground water prior to the plume reaching the Ormet Ranney Well and limit the migration of contaminants from the FSPSA contaminated source area."

3. **SECTION 6.0 DETAILED ANALYSIS OF SITE-WIDE ALTERNATIVES**

* Section 6.3.5.4, Page 6-34, Paragraph 1, is modified to add the following sentence at the end of the paragraph:

  "However, this sludge will be handled and disposed of as hazardous waste because it will still contain cyanide, the hazardous constituent for which the K008 wastes are "listed" wastes. Therefore, OAC 3745-51-03, is a potential ARAR."

* Section 6.10.5, Page 6-317, Paragraph 1 is modified to add the following language after Sentence #1:

  "The new interceptor wells would reduce the toxicity of contaminant concentrations and would reduce the mobility of the plume by limiting migration of the contaminants out of the FSPSA source area. However, the volume of the plume would not be reduced."

  Please note that this language also modifies similar language found in Section 6.11.5, Page 6-359.

4. **SECTION 7.0 COMPARATIVE ANALYSIS OF ALTERNATIVES**

* Table 7-1 has been modified to include two Tables 7-1 and 7-1a. Table 7-1 provides a comparison of each remedial alternative component with the components of the other alternatives. Each alternative component was ranked from Poor to Excellent based on its technical merit for each determining criterion. The Agencies believe this approach provides a comparison of the overall protection, short- and long-term protectiveness, and other important criteria of each remedial alternative. See Attachment #2 for more details. Table 7-1a numerically ranks each remedial alternative. Each remedial alternative was given a score of 1 through 10 (with 10 being the worst ranking) based on its

technical merit as dictated by the nine criteria set forth in the NCP except for cost-effectiveness and state- and community-acceptance. Please note that the compliance with ARARs and the protectiveness criteria are considered yes/no criterias and they have been identified as such in Table 7-1a accordingly. Furthermore, it should be understood that for Alternatives 2 through 10 there compliance with ARARs are contingent upon the modifications provided in this addendum. See Attachment #2 for more details. For example, Remedial Alternative 1 (No Action) is not protective of human health and the environment, it does not comply with ARARs, etc. Therefore, it ranked 10 in each category for a total score of 40. The numerical rankings for each criterion were summed to provide a "total" score for the merit of each alternative. This provides a rough estimate of the technical effectiveness of each alternative since it is impossible to say that Remedial Alternative X is exactly one point better than Remedial Alternative Y. The cost criterion was not included in the ranking, but costs are provided for comparison purposes. Cost should be evaluated/considered with other balancing criteria (i.e. Long-term Effectiveness & Permanence, Reduction of Toxicity, Mobility, & Volume, Short-term Effectiveness, Implementability & Cost).

In summary, the following Remedial Alternatives were given the following Rankings:

Remedial Alternative 1	10
Remedial Alternative 2	9
Remedial Alternative 3	8
Remedial Alternative 4	2
Remedial Alternative 5	6
Remedial Alternative 6	7
Remedial Alternative 7	5 (tie)
Remedial Alternative 8	5 (tie)
Remedial Alternative 9	1
Remedial Alternative 10	3

As previously stated, each alternative was given a rough score on its technical merit. Therefore, each ranking is subjective in nature and is to be used only as guidelines for the reviewer.

* Table 7-2, Page 7-3 has been modified as attached. See ATTACHMENT #3 for more details.

* Section 7.1.1, Page 7-19, Paragraph 2, Sentence #3 is modified, because Ormet Corporation fails to discuss the advantages/disadvantages of implementing GW-5 versus GW-3. Therefore the aforementioned sentence is modified to read:

"Operation of interceptor wells placed closer to the source (GW-5) is projected to result in the reduction of total cyanide concentrations at the pumping wells to or below the MCL in less than the amount of time approximated for GW-3."

* Section 7.1.1, Page 7-20, Paragraph 1, Sentence #1 is modified, because U.S. EPA has determined that the disposal of the sludge from the ground water treatment system will trigger the State ARAR OAC 3745-51-03(A)(2)(f). Therefore, the aforementioned sentence has been modified to read:

  "Sludge from the ground water treatment system will be managed as hazardous waste under OAC 3745-51-03(A)(2)(f)."

* Section 7.2, Page 7-21, is modified to add a new paragraph between Paragraphs #1 & #3 to read:

  "As shown in Tables 7-1 and 7-1a, Alternatives 4, 7, 9, & 10 are protective of human health and the environment and rely more on treatment or removal of hazardous constituents than do other alternatives. For the most part, the remaining alternatives generally address the direct exposure pathways, but rely more on institutional controls which have not been proven to be permanent, and therefore, long-term effectiveness is less certain. Of all the alternatives presented, Alternatives 7, 8 and 9 would offer the most protection over the long-term to human and ecological receptors which would be exposed to ground water since these are the only alternatives which would remove the readily leachable contaminants from the FSPSA soils (the primary source of the ground water plume). The other alternatives rely on institutional controls and containment (capping) of the source areas. If the current ground water measures are not maintained (i.e. high volume pumping of the Ranney and interceptor wells), the water table under the main source area would rise approximately 6 feet or more, releasing a concentrated "slug" of contaminants which would flow to the CAC Ranney Well (if it is operating) or to the Ohio River (if the CAC Ranney Well is shutoff)."

* Section 7.4, Page 7-34, Paragraph 1 is modified to add the following language to the end of Paragraph #1. U.S. EPA feels this modification is necessary to specify for the reader the advantages/disadvantages of all the caps evaluated in this document. Please see General Modification #4 above for additional details. Therefore, U.S. EPA has provided the additional language below:

  "The dual-barrier caps proposed in Alternative 4 would be expected to be the most effective containment alternative in the long-term. This is assumed because the characteristics of FML and compacted soil caps tend to complement each other, so that the long-term effectiveness of the two components together is greater than each alone. In addition, each component tends to back up the other in the event of a failure of either."

* Section 7.4.3, Page 7-47, Paragraph 1, has been modified, because Ormet Corporation inappropriately concluded that alternatives 2 through 10 would be reliable over the long-term, because the Ormet site is part of an operating facility with an established security force and maintenance personnel. Additionally, this section should discuss which alternatives has a greater chance of achieving permanence if implemented at this site. Therefore, the U.S. EPA has deemed the following modifications necessary:

  A. The first sentence is modified to read, "The long-term reliability and permanence achieved by Alternatives 4, 6, 7, 9 and 10 would be greater than that achieved by Alternatives 2, 3, 5 and 8 since the former alternatives rely more upon treatment or removal of hazardous wastes and their associated constituents than does the latter group."

  B. The phrase ".....although the treatment results in removal of soluble contaminants from soil and therefore is permanent," is added to the end of Sentence #10.

* Section 7.4.4, Page 7-48, Paragraph 1 has been modified to include the following sentence between Sentences #3 & #4, because U.S. EPA deemed it necessary to clarify for the reader that contaminant concentrations are higher near the source and therefore pumping near the source would capture a more contaminated plume. Therefore, the additional language has been cited below:

  "However, contaminant concentration of the ground water plume outside of the FSPSA may be reduced more rapidly under Alternatives 9 and 10 by using interceptor wells on the edge of the FSPSA."

* Section 7.5.4, Page 7-55, Paragraph 1, is modified to include the following language between Sentences #1 & #2, because the disposal of treatment residuals, which will be generated from the Stabilization/Solidification of disposal pond solids and backwater area sediments, will trigger the requirements of State ARAR OAC 3745-51-03:

  "This sludge will be so similar to that of K008 listed waste, a hazardous waste containing cyanide, that the sludge must be treated/managed as such pursuant to OAC 3745-51-03."

* Section 7.6.1, Page 7-57, Paragraph 1, is modified to include the following language between Sentences #2 & #3, because U.S. EPA deemed it necessary to identify those alternatives that may pose engineering difficulties during and after installation of a cap (i.e. single, double, synthetic (FML) cap, etc...). Please note that this may occur in Alternatives 3, 5, 8 and 10 due to the absence of treatment/stabilization of the disposal pond solids prior to containment of any hazardous wastes left in place. Therefore, the additional language has been cited below:

  "Construction of the capping components over the FDPs under Alternatives 3,5, 8 and 10 may pose engineering difficulties associated with settlement of the unstable material in the FDPs during and after installation of the cap."

ATTACHMENT 1

DEVELOPMENT OF HEALTH RISK-BASED PRELIMINARY REMEDIATION GOALS FOR THE ORMET CORPORATION SITE

General Approach

Preliminary Remediation Goals (PRGs) are concentration goals for individual chemicals and for specific medium and land use combinations at a Superfund site. The PRGs are chemical specific clean-up levels protective of human health and the environment and comply with chemical specific Applicable or Relevant and Appropriate Requirements (ARARs). There are two general sources of chemical specific PRGS: 1) concentrations based on ARARs and 2) concentrations based on risk assessment. ARARS include concentration limits set by other environmental regulations (e.g., non-zero Maximum contaminant level goals (MCLGs) set under the Safe Drinking Water Act (SWDA)).

The second source of PRGS, and the major focus of this Attachment, is risk assessment or risk-based calculations that set concentration limits using carcinogenic or noncarcinogenic toxicity values under specific exposure conditions. These PRGS are developed to provide long-term targets for remedial design and are used during the Agencies' remedy selection process faor this site. Based on the results of the baseline risk assessment for the Ormet Corporation Site, remediation is required for three media: groundwater, sediments in the backwater area and soils at the Former Disposal Ponds (FDPs), the Former Spent Potliner Storage Area (FSPSA), the Carbon Runoff Deposition Area (CRDA) and the Construction Material Scrap Dump (CMSD). The proposed PRGs for each medium and/or contaminated source area are described as follows.

Proposed PRGs for Soils

The proposed remedial measures for soils at the aforementioned source areas at the Ormet Corporation Site all include eliminating or blocking any future hypothetical exposures (including ingestion, dermal or inhalation exposures) to these materials for either human or ecological populations. When remediation will result in eliminating an exposure (i.e., as by capping the material) it is not necessary to calculate PRGs since the exposure pathway assumed in the risk assessment would be incomplete.

Proposed PRGs for Groundwater

The baseline risk assessment included a future hypothetical resident utilizing groundwater contaminated by the Ormet site. A set of PRGs can be developed based on residential exposures by rearranging the equation which describes risk and solving for a concentration (the PRG) that corresponds to a target risk level. For carcinogens the target risk level ranges from 1E-04 to 1E-06 and for noncarcinogens the target is a Hazard Index of 1.0. However, once an MCL is reached in groundwater, EPA generally considers remediation complete. Since most of the contaminants of potential concern at this site have MCLs, the proposed PRG becomes the MCL. Table 1 shows the estimated carcinogenic risk for each chemical both at the chemical's MCL and at its detection limit. The table illustrates that if all chemicals were remediated to their respective MCL or detection limit (if an MCL is not available) the estimated residual risk would be approximately 1E-03.

For noncarcinogens the same general methodology applies. If arsenic, barium and fluoride are reduced to their respective MCL, those concentrations still represent hazard quotients (HQs) greater than 1.0. The PRGs for vanadium, cyanide and manganese can be calculated by setting their HQs to either 1.0 or 0.5 (the hazard quotients for cyanide and manganese together must total 1.0 since these two chemicals have similar toxic neurological effects). Table 1 indicates the selected PRGs for noncarcinogenic chemicals of potential concern in groundwater.

The summary section of Table 1 selects the most conservative (that is the lowest value) for a chemical among the values calculated for carcinogenic risk and noncancer health effects.

It is not necessary to calculate a PRG designed to be protective of environmental populations since those receptors are not exposed to groundwater.

Proposed PRGs for Sediment

The baseline risk assessment evaluated exposures to sediment for two assumed receptors: a hypothetical trespasser and a future hypothetical resident. By rearranging the equation for risk (including both oral and dermal exposure pathways), PRGs can be calculated for each carcinogenic chemical detected in the sediments in the 004 backwater area. Additivity among chemicals must also be accounted for in these calculations, which means that the target risk level (1E-06) must be apportioned among the seven carcinogens. This apportionment can be achieved in several ways. At this site the target risk was divided approximately equally among the carcinogens. This means that the target risk level in the equation is 1E-06 divided by seven, or 1.4E-07.

Since the baseline risk assessment concluded that noncarcinogens were not contributing to adverse health effects, there is no need to calculate PRGs for noncarcinogenic chemicals detected in the sediments.

Table 2 shows the PRGs resulting from this calculation.

Since the sediments are of ecological significance, the PRGs for sediment must also be protective of environmental populations. The Sediment Quality Criteria (which are protective of ecological receptors) calculated for this site by the Ormet Corporation in Appendix F are higher than the PRGs for human health calculated in this Attachment (Table 2). Only the lower number is protective of both human health and the environment.

It must also be noted that PRGs should take into account additivity across media. The hypothetical future resident could be exposed both to groundwater and the sediments. However, adding the risk at the PRGs for sediment (1E-06) to the risk achievable in groundwater (1.3E-03) does not change total risk to the hypothetical future resident.

TABLE 1 SELECTED PRGS FOR GROUNDWATER, ORRET SITE

Chemical	MCL	Risk at MCL	Det.Limit	Risk at DL	PRG Selection	PRG Value	Risk at PRG
CARCINOGENS							
Arsenic	5.0E-02	1.1E-03	1.0E-02	2.2E-04	MCL	5.0E-02	1.1E-03
Benzene	5.0E-03	1.7E-06	1.0E-02	3.5E-06	MCL	5.0E-03	1.7E-06
Beryllium	4.0E-03	2.1E-04	5.0E-03	2.6E-04	MCL	4.0E-03	2.1E-04
Bis(2-ethylhexyl)phthalate	6.0E-03	1.0E-06	1.0E-02	1.7E-06	MCL	6.0E-03	1.0E-06
Benzo(a)pyrene	2.0E-04	1.8E-05	2.0E-05	1.8E-06	MCL	2.0E-04	1.8E-05
Benzo(a)anthracene	--	0.0E+00	2.0E-05	1.8E-06	DL	2.0E-05	1.8E-06
Chrysene	--	0.0E+00	2.0E-05	1.8E-06	DL	2.0E-05	1.8E-06
Benzo(b)fluoranthene	--	0.0E+00	2.0E-05	1.8E-06	DL	2.0E-05	1.3E-06
Tetrachloroethylene	5.0E-03	3.1E-06	1.0E-02	6.1E-06	MCL	5.0E-03	3.1E-06
	TOTAL	1.3E-03		4.9E-04			1.3E-03
NONCARCINOGENS-SUBCHRONIC							
Arsenic	5.0E-02	2.2E+01	1.0E-02	4.3E+00	MCL	5.0E-02	2.2E+01
Barium	2.0E+00	5.2E+00	2.0E+00	5.2E+00	MCL	2.0E+00	5.2E+00
Cyanide	--	0.0E+00	1.0E-02	6.5E-02	HQ=0.5	7.7E-02	5.0E-01
Fluoride	4.0E+00	8.7E+00	1.0E-01	2.2E-01	MCL	4.0E+00	8.7E+00
Manganese	--	0.0E+00	1.5E-02	2.0E-02	HQ=0.5	3.8E-01	5.0E-01
Vanadium	--	0.0E+00	5.0E-02	9.3E-01	HQ=1.0	5.4E-02	1.00E+00
NONCARCINOGENS-CHRONIC							
Arsenic	5.0E-02	4.5E+00	1.0E-02	9.0E-01	MCL	5.0E-02	4.5E+00
Cyanide	--	0.0E+00	1.0E-02	1.4E-02	HQ=1.0	7.4E-01	1.0E+00
Fluoride	4.0E+00	1.8E+00	1.0E-01	4.5E-02	MCL	4.0E+00	1.8E+00

SUMMARY OF SELECTED PRGs, mg/L

Arsenic	5.0E-02
Barium	2.0E+00
Benzene	5.0E-03
Beryllium	4.0E-03
Bis(2-ethylhexyl)phthalate	6.0E-03
Benzo(a)pyrene	2.0E-04
Benzo(a)anthracene	2.0E-05
Benzo(b)fluoranthene	2.0E-05
Chrysene	2.0E-05
Cyanide	7.7E-02
Fluoride	4.0E+00
Manganese	3.8E-01
Vanadium	5.4E-02

TABLE 2 SELECTED PRGS FOR SEDIMENT, ORMET
(Target risk level: 1E-06)

Chemical	Calculated PRG, mg/kg Trespasser	Resident
Benzo(a)anthracene	1.1E+01	4.3E+00
Benzo(a)pyrene	1.1E+01	4.3E+00
Benzo(b)fluoranthene	1.1E+01	4.3E+00
Benzo(k)fluoranthene	1.1E+01	4.3E+00
Chrysene	1.1E+01	4.3E+00
Ideno(1,2,3-cd)pyrene	1.1E+01	4.3E+00
Polychlorinated biphenyls (PCBs)	7.4E-02	4.8E-02

ATTACHMENT 2

TABLE 7-1 (REVISED)
SUMMARY OF REMEDIAL ALTERNATIVE EVALUATION

Remedial Alternative	Components of Remedial Alternative	Overall Protection of Human Health and the Environment (Y/N)	Compliance with ARARs (Y/N)	Long-Term Effectiveness and Permenence	Reduction of Toxicity, Mobility or Volume	Short-Term Effectiveness	Implementability	PW Cost
1	No Action	No	No	Poor	Poor	Poor	Poor	$0
2	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-2 soil cover	Yes	Yes*	Fair-Good	Fair	Good	Very Good	
	FDP-2 soil cover	Yes	Yes*	Fair-Good	Fair	Good	Very Good	
	CMSD-3 soil cover	Yes	Yes*	Fair-Good	Fair	Good	Very Good	
	CRDA-3 excav., consol.	Yes	Yes	Good	Good	Good	Very Good	
	and soil cover							
	SED-6 sht. pil. and rev.	Yes	No	Good	Fair	Good	Very Good	$15.4M
3	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-4 synth. cap	Yes	Yes	Very Good	Fair-Good	Good	Very Good	
	FDP-5 synth. cap	Yes	Yes	Very Good	Fair-Good	Good	Very Good	
	CMSD-4 synth. cap	Yes	Yes	Very Good	Fair-Good	Good	Very Good	
	CRDA-3 excav., consol.	Yes	Yes	Very Good	Fair-Good	Good	Very Good	

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	and synth. cap							
	SED-8 dredg., solid.,	Yes	Yes+	Very Good	Fair-Good	Good	Good	
	consol. w/CMSD							
	and contain.							$19 .4M
4	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-3 dual barrier cap	Yes	Yes	Excellent	Good	Very Good	Very Good	
	FDP-7 dual barrier cap	Yes	Yes	Excellent	Good	Very Good	Very Good	
	CMSD-5 dual barrier cap	Yes	Yes	Excellent	Good	Very Good	Very Good	
	CRDA-3 excav., consol.	Yes	Yes	Excellent	Good	Very Good	Very Good	
	and dual barrier cap							
	SED-8 complete dredg.,	Yes	Yes	Excellent	Good	Very Good	Good	
	solid. and consol.							
	w/CMSD and contain.							$32 .4M
5	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-9 part. excav. w/	Yes	Yes	Very Good	Very Good	Good	Very Good	
	off-site disposal							
	synth. cap							

	FDP-5 synth. cap	Yes	Yes	Very Good	Fair-Good	Good	Very Good	
	CMSD-4 synth. cap	Yes	Yes	Very Good	Fair-Good	Good	Very Good	
	CRDA-3 excav., consol.	Yes	Yes	Very Good	Good	Good	Very Good	
	and contain.							
	SED-8 dredg., solid.,	Yes	Yes+	Very Good	Fair-Good	Good	Good	
	consol. w/CMSD							
	and contain.							$21 .4M
6	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-9 part. excav.,	Yes	Yes	Very Good	Good	Good	Very Good	
	contain. by synth. cap							
	FDP-3 stabil. and soil	Yes	Yes*	Good	Good	Good	Very Good	
	cover							
	CMSD-7 complete excav.,	Yes	Yes	Excellent	Very Good	Good	Fair	
	therm. oxid., synth.							
	cap							
	CRDA-5 excav., therm.	Yes	Yes	Excellent	Very Good	Good	Fair	
	oxidation							
	SED-7 complete dredg.,	Yes	Yes+	Very Good	Good	Good	Good	
	solid. and consol.							$12 3M

7	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-6 In-situ soil	Yes	Yes	Good	Good	Good	Good	
	flush., contain. by							
	veg. soil cover							
	FDP-7 solid. and dual	Yes	Yes	Very Good	Very Good	Good	Very Good	
	barrier cap							
	CMSD-7 complete excav.,	Yes	Yes	Very Good	Very Good	Good	Fair	
	therm. oxid., synth.							
	cap							
	CRDA-5 excav., therm.	Yes	Yes	Very Good	Very Good	Good	Fair	
	oxidation							
	SED-9 complete dredg.,	Yes	Yes	Very Good	Good	Good	Good	
	treat. by solvent							
	extract., consol. w/							
	CMSD, synth. cap							$12 4M
8	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-6 In-situ soil	Yes	Yes	Excellent	Good	Good	Good	
	flush., contain. by							
	synth. cap							
	FDP-5 contain. by synth.	Yes	Yes	Very Good	Good	Good	Very Good	
	cap							

	CMSD-4 recontour. and	Yes	Yes	Very Good	Good	Good	Very Good	
	contain. by synth.							
	cap							
	CRDA-3 excav., consol.,	Yes	Yes	Very Good	Good	Good	Good	
	and contain. by							
	synth. cap							
	SED-8 part. dredg.,	Yes	Yes+	Very Good	Good	Good	Good	
	solid., consol. w/							
	CMSD and contain.							$19 .4M
9	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-9 part. excav. w/	Yes	Yes	Excellent	Very Good	Good	Good	
	l.f., contain. by							
	synth. cap							
	FBP-7 solid., contain.	Yes	Yes	Very Good	Good	Good	Good	
	by synth. cap							
	CMSD-7 compl. excav.,	Yes	Yes	Excellent	Very Good	Good	Fair	
	therm. oxid., contain.							
	by synth. cap							
	CRDA-4 excav. w/l.f.	Yes	Yes	Very Good	Very Good	Good	Good	
	SED-4 compl. dredg.,	Yes	Yes	Excellent	Very Good	Good	Good	
	solid., l.f. of							

	dredged sediments							$14 5M
10	GW extr. and treat.	Yes	Yes	Excellent	Good	Excellent	Excellent	
	Collect./treat. of seeps	Yes	Yes	Excellent	Good	Excellent	Excellent	
	FSPSA-10 contain. by	Yes	Yes	Very Good	Good	Good	Very Good	
	single barrier							
	clay cap							
	FDP-10 contain. by	Yes	Yes	Very Good	Good	Good	Very Good	
	single barrier							
	clay cap							
	CMSD-8 recontour. and	Yes	Yes	Very Good	Good	Good	Very Good	
	contain. by single							
	barrier clay cap							
	CBDA-3 excav., consol.,	Yes	Yes	Very Good	Good	Good	Very Good	
	contain. by single							
	barrier clay cap							
	SED-10 dredg. backwater	Yes	Yes	Very Good	Good	Good	Good	
	area and river sedim.,							
	treat. by solid.,							
	consol. w/CMSD,							
	and contain.							$48 M

* - Meets federal ARARs for solid waste, but not State of Ohio ARARs

+ - May not attain TBC-based clean-up goals

TABLE 7-1a
SUMMARY OF REMEDIAL ALTERNATIVE EVALUATION

Remedial Alternative	Components of Remed. Alternative	Overall Protect. Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness & Permanence	Reduction of Toxicity, Mobility / Volume	Short-Term Effectiveness	Implement.	Overall Score	PW Cost
1	No Action	NO	NO	10	10	10	10	40	$0
2	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-2 soil cover								
	FDP-2 soil cover								
	CMSD-3 soil cover								
	CRDA-3 excav., consol.								
	and soil cover								
	SED-6 sht. pil. and rev.	Yes	YES	9	9	9	1	28	$15.4 M
3	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-4 synth. cap								
	FDP-5 synth. cap								
	CMSD-4 synth. cap								
	CRDA-3 excav., consol.								
	and synth. cap								
	SED-8 dredg., solid.,								
	consol. w/CMSD								

	and contain.	Yes	YES	8	8	8	2	26	$19.4 M
4	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-3 dual barrier cap								
	FDP-7 dual barrier cap								
	CMSD-5 dual barrier cap								
	CRDA-3 excav., consol.								
	and dual barrier cap								
	SED-8 complete dredg.,								
	solid. and consol.								
	w/CMSD and contain.	Yes	YES	5	6	1	3	15	$32.4 M
5	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-9 part. excav. w/								
	off-site disposal								
	synth. cap								
	FDP-5 synth. cap								
	CMSD-4 synth. cap								
	CRDA-3 excav., consol.								
	and contain.								
	SED-8 dredg., solid.,								
	consol. w/CMSD								
	and contain.	Yes	YES	6	7	4	5	22	$21.4 M

6	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-9 part. excav.,								
	contain. by synth. cap								
	FDP-3 stabil. and soil								
	cover								
	CMSD-7 complete excav.,								
	therm. oxid., synth.								
	cap								
	CRDA-5 excav., therm.								
	oxidation								
	SED-7 complete dredg.,								
	solid. and consol.	Yes	YES	1	3	7	8	24	$123M
7	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-6 In-situ soil								
	flush., contain. by								
	veg. soil cover								
	FDP-7 solid. and dual								
	barrier cap								
	CMSD-7 complete excav.,								
	therm. oxid., synth.								
	cap								
	CRDA-5 excav., therm.								
	oxidation								

	SED-9 complete dredg.,								
	treat. by solvent								
	extract., consol. w/								
	CMSD, synth. cap	Yes	YES	2	2	6	9	19	$124M
8	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-6 in-situ soil								
	flush., contain. by								
	synth. cap								
	FDP-5 contain. by synth.								
	cap								
	CMSD-4 recontour. and								
	contain. by synth.								
	cap								
	CRDA-3 excav., consol.,								
	and contain. by								
	synth. cap								
	SED-8 part. dredg.,								
	solid., consol. w/								
	CMSD and contain.	Yes	YES	7	4	3	6	19	$19.4 M
9	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-9 part. excav. w/								
	l.f., contain. by								

	synth. cap								
	FDP-7 solid., contain.								
	by synth. cap								
	CMSD-7 compl. excav.,								
	therm. oxid., contain.								
	by synth. cap								
	CRDA-4 excav. w/l.f.								
	SED-4 compl. dredg.,								
	solid., l.f. of								
	dredged sediments	Yes	YES	3	1	2	7	14	$145M
10	GW extr. and treat.								
	Collect./treat. of seeps								
	FSPSA-10 contain. by								
	single barrier								
	clay cap								
	FDP-10 contain. by								
	single barrier								
	clay cap								
	CMSD-8 recontour. and								
	contain. by single								
	barrier clay cap								
	CRDA-3 excav., consol.,								
	contain. by single								
	barrier clay cap								
	SED-10 dredg. backwater								
	area and river sedim.,								
	treat. by solid.,								
	consol. w/CMSD,								
	and contain.	Yes	YES	4	5	5	4	18	$40M

ATTACHMENT #3

Table 7-2 is modified in the revised Table 7-2 and/or as follows:

"U" for Attainment is uncertain has been added

OAC:1501-21-5, -11, -13, -15, -21

The ability of alternatives 2 through 10 to attain these potential ARARs is uncertain because the levee has not yet been characterized. However, if any one of these alternatives is selected as the remedy for the site, it will designed to meet these potential ARARs.

OAC:3745-1-04(D)

The ability of alternatives 2,3,5, and 8 to attain this potential ARAR is uncertain because PCBs and PAHs may slowly leach out from these containment remedies.

OAC:3745-1-06

This regulation is an administrative requirement and is, therefore, not a potential ARAR.

OAC:3745-1-32

This regulation is not a potential ARAR, but is a TBC because it identifies the designated uses of the Ohio River.

OAC:3745-9-11

This regulation is not a potential ARAR because no alternative involves the use of ground water wells for disposal.

OAC:3745-18-04 A, B, C, E, F

This regulation is added, is not pertinent to alternatives 1, 2, 3, 4, 5, 8, and 10, and will be attained by alternatives 5, 6, and 9.

OAC:3745-19-04

This regulation is not a potential ARAR because none of the alternatives include open burning.

OAC:3745-21-03 B,C,D, Methods of Ambient Air Quality Measurement, OAC:3745-23-01, Nitrogen Dioxide Ambient Air Quality Standards and OAC:3745-23-02 a,b, Measurement Methods for Nitrogen Dioxide are added as potential ARARs.

OAC:3745:27-07 A, B

These regulations are not environmental standards, and are administrative in nature. Additionally, no permit is required for on-site activity. Therefore, these regulations are not ARARs.

OAC:3745-27-08 C, D, Construction Specifications for Sanitary Landfills and OAC:3745-27-09 C, L, N, O, Sanitary Landfill Facility Operations replace the references to these citations in the original Table 7-2, and are pertinent to the alternatives which include additional waste being placed in the CMSD.

OAC:3745-27-10 B,C,D
Alternative #4 would attain this requirement.

OAC:3745-27-11 B,G
Alternative #4 will attain this requirement. Alternative #s 2,3,5,6,7,8,9, and 10 will be designed to meet these regulations.

OAC:3745-27-11A
This regulation is an administrative requirement and is, therefore, not a potential ARAR.

OAC:3745-27-12B, -13E-G,J
These regulations are administrative requirements and are, therefore, not potential ARARs.

OAC:3745-27-14A
Alternative #4 will attain this potential ARAR.

OAC:3745-50-44, -44B, -44C1, -44C2, -44C3, -44C4, -44C5, -44C6, -44C7, -44C8, -44C9
No permit is required for on-site remedial actions and these requirements are not environmental standards. Rather, they are administrative requirements and, therefore, are not potential ARARs.

OAC:3745-50-58 A,H
These regulations are not potential ARARs because no permit is required for on-site remedial actions and because they are administrative requirements.

OAC:3745-50-221 A,B Petitions to Exclude Listed Waste at a Facility has been deleted because it is not a potential ARAR.

OAC:3745-52-20, -22, -23, -30, -31, -32, -33, -34
These regulations are pertinent to all alternatives which contemplate the transportation of hazardous waste off-site and are, therefore, added as potential ARARs.

OAC:3745-54-14 A,B,C and -15 A,B
Alternatives 2 through 10 will attain these requirements.

OAC:3745-54-18 A,C
These regulations are not potential ARARs for this site because the site is not located within 61 meters of a fault which has had displacement in Halocene times, nor in a location where salt domes/bed formations, underground mines, or cases are present.

OAC:3745-54-18B
Alternative 2 will not attain this potential ARAR. Alternatives 3, 4, 5, 6, 7, 8, 9, and 10 will be designed to attain this potential ARAR.

OAC:3745-54-32, -33, -34, -35, -37

These regulations may be independently applicable safety requirements, but because they are not environmental standards, they are not potential ARARs.

OAC:3745-54-52, -53, -54, -55, -56
These regulations are not potential ARARs because no permit is required for on-site activities and becuase they are not environmental standards.

OAC:3745-54-94, -95, -96, -97, -98, -99
Alternatives 2 through 10 will attain this potential ARAR.

OAC:3745-55-01, -11
Alternatives 2 through 10 will attain this potential ARAR.

OAC:3745-55-12, -16, -18, -19
These regulations are not potential ARARs for this site becuase no permit is required for on-site activity, the requirements are administrative requirements, and they are not environmental standards.

OAC:3745-55-14, -17B
Alternatives 2 through 10 will attain this potential ARAR.

OAC:3745-55-71, -72, -73, -74, -75, -76, -78
Alternatives 2 through 10 will attain these potential ARARs.

OAC:3745-55-92, -93, -94, -95, -96, -97, -98
These regulations are not potential ARARs because none of the alternatives employ a tank system.

OAC:3745-56-21, -26, -27
These regulations are not potential ARARs for this site because they pertain to new surface impoundments.

OAC:3745-56-28 A, B, C
Alternatives 2, 3, 5, 6, 8 and 10 will not attain this potential ARAR because they do not demonstrate that they have 1) a bearing capacity to support the final cover, 2) that the covers will provide long-term minimization of the migration of liquids through the closed impoundment, and 3) that they accomodate settling and subsidence, as specified in the regulation.

OAC:3745-56-51, -54, -56, -58, -59
These regulations have been deleted from the list of potential ARARs.

OAC:3745-59-07, Waste Ananlysis and Recordkeeping
This regulation has been added an a potential ARAR.

OAC:3745-59-40 A, B, C, -41 A, -42 A, C, D, -43 A, B, C
These regulations have been added as potential ARARs.

OAC:3745-81-14, -15, -16, -21, -25, -26, -40, -46

These regulations have been deleted as potential ARARs.

ORC:3734.03
This regulation, which prohibits open dumping or burning is added as a potential ARAR.

ORC:3734.05(D)(6)(c), (d), ORC:6101.19, ORC:6111.043, ORC:6111.45
These sections have been deleted from the list of potential ARARs.

ORC:3767.13, 3767.14 Prohibits nuisances in waterways.
These sections are added as potential ARARs.

ORC:3704.06, which prohibits violation of air pollution control rules has been added as a potential ARAR.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:150121-5 02-06	*Design requirements of dams, dikes and levees	NP	U	U	U	U	U	U	U	U	U
OAC:1501:21-11 03-05	Predesign investigations (dams, dikes, levees)*	NP	U	U	U	U	U	U	U	U	U
OAC:1501:21-13 02-08	Additional design requirements for dams*	NP	U	U	U	U	U	U	U	U	U
OAC:1501:21-13 10-14	Additional design Requirements for dikes and levees*	NP	U	U	U	U	U	U	U	U	U
OAC:1501:21-15 06	Operation, maintenance and inspections	NP	U	U	U	U	U	U	U	U	U
OAC:1501:21-21 03-04	Deficiency and O&M of dams, dikes and levees	NP	U	U	U	U	U	U	U	U	U
OAC:3745-1-03	Analytical and Sample Collection procedures	NP	A	A	A	A	A	A	A	A	A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain* As stated in general modification #2, alternatives which incorporate use of the levee and rip rap or concrte revetments will be *designed to meet this potential* ARAR. Currently, little is *known about* the levee, it is *currently uncertain* whether the alternatives as presented will meet this ARAR. Additional work on the levee may by necessary.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-1-04	The "Five Freedoms" for surface water	NA	U	U	U	U	U	U	U	U	U
OAC:3745-105	Antidegradation Policy for surface water	NA	A	A	A	A	A	A	A	U	U
OAC:3745-9-04 A,B	Location/siteing new ground water wells	NP	NP	NP	NP	NP	NP	NP	NP	A	A
OAC:3745-9-05 A1,B-H	Construction of new ground water wells	NP	NP	NP	NP	NP	NP	NP	NP	A	A
OAC:3745-9-06 A,B,D,E	Casing requirements for new ground water wells	NP	NP	NP	NP	NP	NP	NP	NP	A	A
OAC:3745-9-07 A-F	Surface design of new ground water wells	NP	NP	NP	NP	NP	NP	NP	NP	A	A
OAC:3745-9-08 A,C	Start-up &operation of ground-water wells	NP	NP	NP	NP	NP	NP	NP	NP	A	A
OAC:3745-9-09 A-C,D1, E-G	Maintenance & Operation of ground-water wells	NP	A	A	A	A	A	A	A	A	A
OAC:3745-9-10-A,B,D	Abandonment of test holes & ground water wells	NP	A	A	A	A	A	A	A	A	A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-15-06 A1,A2	Malfunction and maintenance of air pollution control equipment	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-15-07(A)	Prohibition of air pollution nuisances	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-16-02 B,C	Stack height requirements	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-17-02 A,B,C	Particulate ambient air quality standards	NA	A	A	A	A	A	A	A	A	A
OAC:3745-17-05	Particulate non-degradation policy	NA	A	A	A	A	A	A	A	A	A
OAC:3745-17-07 A-D	Visible particulate emission control	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-17-08 A1,A2,B,D	Emission restrictions for fugitive dust	NP	A	A	A	A	A	A	A	A	A
OAC:3745-17-09 A,B,C	Incinerator particulate emissions and odor restrictions	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-17-10-A,B,C	Fuel burning particulate emission restrictions	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-18-02 A,B,C,D	Sulfur dioxide ambient air quality standards	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-18-04 A,B,C,E,F	Sulfur dioxide measurements methods and procedures	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-18-05 A	Sulfur dioxides ambient monitoring requirements	NP	NP	NP	NP	NP	A	A	NP	A	NP

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-18-06 A-G	Sulfur dioxide emission limit provisions	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-02 A,B,C	Ambient air quality standards for carbon dioxides	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-03 B,C,D	Methods of Ambient Air Quality Measurement	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-05	Carbon monoxide non-degradation policy emission control	NA	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-07 A-J	Organic material emission control stationary source	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-08	Carbon monoxide emission control	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-21-09	VOC emission control: stationary source	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-23-01	Nitrogen dioxide ambient air quality standards	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-23-02 A,B	Measurement methods for nitrogen dioxide	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-23-04	Nitrogen dioxide (NOx)Nondegradation policy	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-23-06	Nitrogen dioxide emission control	NP	NP	NP	NP	NP	A	A	NP	A	NP
OAC:3745-25-03	Emission control action programs	NP	NP	NP	NP	NP	A	A	NP	A	NP

A-Will be attained. NA-Would not be attained. NP-Notpertinent to this alternative. U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent *Paragraph*	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-27-03 B	Exemption to Solid Waste Regulation	NP	NA	A	A	A	A	A	A	A	A
OAC:3745-27-05 A,B,C	Authorized, limited & prohibited solid waste disposal	NP	NA	A	A	A	A	A	A	A	A
OAC:3745-27-08 C,D	Construction specs for sanitary landfills	NA	NA	A	NP	A	A	A	A	A	A
OAC:3745-27-09 C,L,N,O	Sanitary landfill facility operations	NA	NA	A	NP	A	A	A	A	A	A
OAC:3745-27-10 B,C,D	Sanitary landfill ground-water monitoring requirements	NA	A	A	A	A	A	A	A	A	A
OAC:3745-27-11 B,G	Final closure of sanitary landfills	NA	NA	A	A	A	A	A	A	A	A
OAC:3745-27-13 A	Disturbances where solid or hazardous waste facility was operated	NP	A	A	A	A	A	A	A	A	A
OAC:3745-27-14 A	Post-closure care of sanitary landfill facilities	NA	A	A	A	A	A	A	A	A	A
OAC:3745-50-58 E	Hazardous waste facility permit conditions	NP	A	A	A	A	A	A	A	A	A
OAC:3745-50-62 A,B,C,D	Trial burn for incinerators	NP	NP	NP	NP	NP	A	A	NP	A	NP

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.
*-Will be designed to attain. Currently, those alternatives do not attain this potential ARAR because they do not use compacted soil caps and "equivalency" has not been demonstrated

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-51-07 A,B	Residues of hazardous wastes in empty containers	NP	A	A	A	A	A	A	A	A	A
OAC:3745-52-11 A-F	Evaluation of wastes	NP	A	A	A	A	A	A	A	A	A
OAC:3745-52-22, 23,30,31,32,33,34	Manifests,Packaging, Labeling	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-13 A	General Analysis of hazardous wastes	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-14 A,B,C	Security for hazardous wastes facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-15 A,C	Inspection requirements for hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-18 B	Location standards for hazardous waste T/S/D facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-31	Design and operation of hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.
*-Will be designed to attain. Currently, those alternatives do not attain this potential ARAR because they do not use compacted soil caps and "equivalency" has not been demonstrated

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-54-91 A	Regulatory ground-water programs for hazardous waste facilities	NP	A	A	A	A	A	A	A	A	NP
OAC:3745-54-92	Ground-water protection standard; Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-93 A,B	Hazardous constituents in ground water, hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-94 A,B	Concentration limits for ground water, Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-95 A,B	Point of compliance; for ground-water, Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-96 A,B,C	Compliance period for ground water; Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
											A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-55-011	Corrective action for waste management units	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-71	Condition of containers	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-72	Compatability of waste with containers	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-73	Management of containers	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-74	Container inspections	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-75 A,B,C,D	Container storage area containment system	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-76	Container requirements for ignitable/reactive wastes	NP	A	A	A	A	A	A	A	A	A
OAC:3475-55-78	Container closure requirements	NP	A	A	A	A	A	A	A	A	A
OAC:3745-56-28 A,B,C	Management of hazardous wastes in surface impoundments	NP	NA	NA	A	NA	NA	A	NA	A	NA
OAC:3745-57-01 A-D	Environmental performance standards-land-based units	NP	NA	NA	A	NA	NA	NA	NA	NA	NA
57-03 A-I, 57-05 A,B 57-10 A,B,57-12 A,B 57-17 A	Management of hazardous waste in landfills	NP	NP	NP	A	A	A	A	A	A	NP

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-54-97 A-H A-F	General ground-water monitoring requirements; Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-98 A-I A-F	Ground water detection monitoring program; hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-54-99 A-J	Ground-water compliance monitoring program Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-01 A-F	Ground-water corrective action program; Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-11 A,B,C	General closure performance standard; Hazardous waste facilities	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-14 B	Disposal and decontamination of equipment, structures, and soils	NP	A	A	A	A	A	A	A	A	A
OAC:3745-55-17 B	Post-closure care and use of the property	NP	A	A	A	A	A	A	A	A	A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
OAC:3745-57-41 A,B 57-42 A,B,C 57-43 A, B,C 57-44C 57-45 A-F 57-47 A,B,C	Treatment of hazardous waste in incinerators	NP	A	A	A	A	A	A	A	A	A
OAC:3745-57-51	Closure of incinerators	NP	A	A	A	A	A	A	A	A	A
OAC:3745-59-07	Waste analysis of hazardous waste	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81 11 A,B	Maximum contaminant levels for inorganic chemicals	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81 12 A,B,C	Maximum contaminant levels for organic chemicals	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81-13 A,B	Maximum contaminant levels for turbidity	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81-22 A	Turbidity sampling and analytical requirements	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81-23 A	Inorganic monitoring requirements	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81-24 A-E	Organic monitoring requirements	NP	A	A	A	A	A	A	A	A	A
OAC:3745-81-27 A,B,C	Analytical techniques	NP	A	A	A	A	A	A	A	A	A
OAC:3767.13	Prohibition of Nuisances	NP	A	A	A	A	A	A	U	U	U
ORC:1521.06	Construction permits for dams, dikes and levees	NP	U	U	U	U	U	U	U	U	U
ORC:1521.062	Monitoring, maintenance & operation (dams, dikes, levels)	NP	U	U	U	U	U	U			

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial Alternatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
ORC 3734.02(F)	Unauthorized storage, treatment, or disposal of hazardous waste	NP	A	A	A	A	A	A	A	A	A
ORC 3734.02(H)	Earth moving activity where hazardous or solid waste facility was located	NP	A	A	A	A	A	A	A	A	A
ORC 3734.03(I)	Air emissions from hazardous waste facilities	NP	NP	NP	NP	NP	A	A	NP	A	NP
ORC 611.04	Acts of pollution prohibited	NP	A	A	A	A	A	A	A	U	U
ORC 611.042	Requirements for compliance with National Effluent Standards	NP	A	A	A	A	A	A	A	U	U
40CFR 760.60(a)(5) *	PCB Disposal Requirements for Dredged Materials	NP	NP	NP	A	NP	A	A	NP	A	A
40CFR 760.60(e) *	PCB Disposal Requirements for Treatment Other than Incineration	NP	NP	NP	A	NP	A	A	NP	A	A
40CFA 761.70 *	Incineration	NP	NP	NP	NP	NP	A	A	NP	A	NP

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U-Uncertain.

Table 7-2 Comparison of ARAR Compliance for Remedial ernatives at the Ormet Site

Regulatory Citation/Pertinent Paragraph	Title/Subject of Regulation	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7	Alt. 8	Alt. 9	Alt. 10
40CFR 761.75 *	Chemical Waste Landfill	NP	NP	NP	NP	NP	NA	NA	NP	NA	A
40CFR 50.6	National Ambient Air Quality Standards for Particulate Matter	NP	A	A	A	A	A	A	A	A	A
40CFR 268	Land disposal Regulation	NP	A	A	A	A	A	A	A	A	A

A-Will be attained.
NA-Would not be attained.
NP-Notpertinent to this alternative.
U Uncertain.

* If the PCB contamination in the dredged sediments exceeds 50 ppm, then such dredged materials will have to be treated to below 50ppm prior to disposal; or will have to be incinerated (or disposed of by an equivalent method or disposed of in a chemical waste landfill as set forth in these regulations